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DEVELOPMENT OF ROBOTICS FACILITY
DOCKING TEST HARDWARE

Contract NAS8-34656

(NASA-CR-171153) DEVELOPMENT OF ROBOTICS
FACILITY DOCKING TEST HARDWARE Final Report
(Essex Corp.) 106 p HC A06/MF A01 CSCL 14B

N84-33433

Unclas
G3/14 24041

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August 31, 1984

Essex Report Number H-84-05





FOREWORD

This final report represents the results of a 12-month effort by Essex Corporation to design and fabricate test hardware for NASA's George C. Marshall Space Flight Center (MSFC) under contract NAS8-34656. A docking device conceptually developed by Essex for MSFC under contract NAS8-33073 was fabricated. Also, two docking targets providing high and low mass docking loads were required and were represented by an aft 61.0 cm section of a Hubble Space Telescope (ST) mockup and an upgrading of an existing Multimission Modular Spacecraft (MMS) mockup respectively. In addition, a test plan was developed for testing the above-mentioned hardware.

The support and guidance provided by Ed Guerin (EB14), the contract COR, and Richard Cloyd (EP36) were especially helpful in the performance of the hardware design, and the assistance of Frank Vinz (EB44) in interfacing with the 6 DOF equipment in MSFC's Building 4663 was both timely and appreciated.

The assistance of John Haslam, David Henderson, Keith Savas, and Nicholas Shields in fabricating and integrating the mockups in the Teleoperator and Robotics Evaluation Facility is gratefully acknowledged. Appreciation is also extended for their preparation of the Test Requirements section of this report.

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1.0 INTRODUCTION

1.1 BACKGROUND

Prior to the successful retrieval, repair, and release of the Solar Maximum Mission (SMM) satellite during Shuttle Mission 41-C, all spacecraft docking has been performed on a manual vehicular level with one or more onboard crew members piloting the chase vehicle and operating the docking hardware. The use of the Remote Manipulator System (RMS) for retrieval of the SMM demonstrated the feasibility of remote docking. This technique had certain elements in common with both the manned chase vehicle/target capture and totally remote docking systems in that the Orbiter had to be positioned within capture distance of the target satellite and the crewmember was required to remotely "pilot" the end effector of the RMS into a capture position in order to secure the target.

These docking techniques have proven feasible in prior missions and will, in all probability, continue to be used in the future when appropriate. However, there are situations in which neither method of docking will suffice. These include: 1) the capture of a satellite which is beyond the operating range of the Orbiter/RMS reach envelope, 2) the capture of satellites which may be sensitive to concentrations of contaminants found near an actively maneuvering Orbiter, and 3) satellites which may present a hazard to the Orbiter or crew through malfunction or design. Thus, the development of truly remote docking hardware and techniques will allow a wide range of docking scenarios to be enacted.

The development of prototypical docking hardware, as well as realistic docking targets (i.e., ST and MMS) which have well defined berthing pins, was therefore necessary to expand the development of remote crew station configurations, training procedures, lighting and video constraints and parameters which has been an on-going activity at MSFC since 1972.

The Teleoperator and Robotics Evaluation Facility (TOREF, MSFC Bldg. 4619), and the six degree of freedom (6DOF) simulator (MSFC Bldg. 4663) provide facilities for a wide range of evaluation and development techniques concerning remote docking.

1.2 SCOPE

The purposes of this contract were to: 1) provide a full-size mockup of the ST aft end to represent a large, massive docking target, 2) upgrade the existing MMS to represent a smaller, less massive docking target, 3) fabricate the three-element docking device designed under a previous Essex/MSFC contract to mate with both spacecraft docking targets, and 4) identify the docking test requirements.



2.0 TASK DESCRIPTIONS

Four contract tasks were performed as described below.

2.1 TASK 1 - DEVELOPMENT OF SPACE TELESCOPE MOCKUP

A full size mockup of the ST aft end (Figure 2.1 and Appendix A) was constructed using drawings obtained from Lockheed Missile and Space Company as well as Interface Control Documents (ICDs) obtained from MSFC engineering personnel. The ICDs were used in the design of the three berthing pins as no machine drawings were available.

The frame of the main cylinder of the ST mockup was constructed primarily of 3.2 mm thick aluminum architectural angle formed and welded into three wedge-shaped sections 61.0 cm thick (see Appendix A). Internal bracing provided a rigid, lightweight structure (<100 kg) on which the berthing pins, vents, connector tower, docking target, and handrails were mounted. Mounting to the gimbal system for roll, pitch, and yaw was accomplished through the use of a central support tube which also added rigidity and served as an attach point for the diagonal and radial support members. All external surfaces of the mockup were covered with corrugated fiberboard, which served as a base for attachment of the simulated insulation blanket as well as a mounting surface for some of the lighter visual features. The corrugated fiberboard was attached to the frame with large head pop rivets.

The insulation blanket which covers the ST was simulated by 6.4 mm thick bubble-type plastic packaging material covered with .05 mm adhesive-backed metalized mylar film. The result was a bright silver specular finish which closely approximated samples of the actual insulation blanket obtained from MSFC engineering personnel.

The berthing pins (Dwg. No. 471 '01, Appendix A) were constructed of stainless steel pipe which was machined on the outside surface to provide the proper 3.81 cm outside diameter and resulted in a wall thickness of 4.6 mm. The supporting brackets were machined from single billets of 6061-T6 aluminum alloy.

A review of design requirements for mounting the berthing pins above the 6 DOF simulator revealed the desirability of constructing an additional structure for this purpose rather than utilizing a dual purpose berthing pin mount as originally proposed. The benefits gained from this approach included: 1) more structural integrity of the flat floor ST mockup, and 2) ease of transfer of the ST mockup from one facility to the other without disassembly. This structure was fabricated at no additional expense to MSFC.

The support stand for the ST mockup underwent several design modifications due to changes in its location on the perimeter of the epoxy flat floor. Early in the design phase it was decided that the

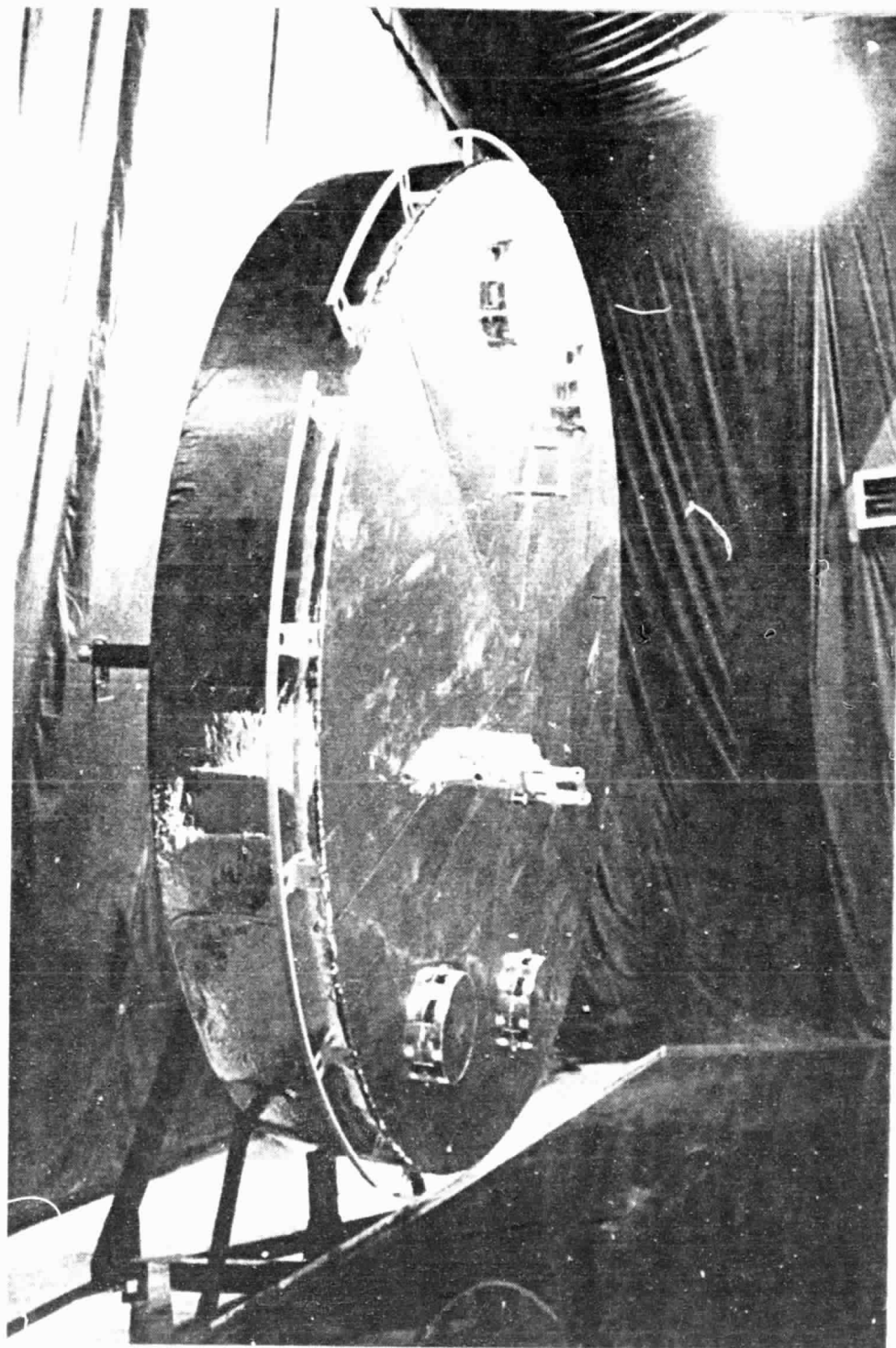


Figure 2.1: ST Mockup Installed on Perimeter of Air
Bearing Flat Floor

addition of yaw in the support structure was advisable in order to compensate for torsional stresses anticipated during testing with the Teleoperator Motion Base (TOM-B). Likewise, a bearing system was provided to allow the mockup to be lifted vertically (Z axis) as much as 45.7 cm. This feature was provided as a precaution to avoid damage in the event that a + Z command was given the TOM-B after docking had been accomplished.

The stand was mounted to the concrete floor adjacent to the epoxy floor using 3/8-inch lead anchors. Additional tie downs were provided at the rear of the base to assure that the structure did not tip over.

2.2 TASK 2 - MODIFICATION AND INSTALLATION OF MMS MOCKUP

The original contract required the upgrading of the existing wood and foam core mockup of the aft end of the MMS. An on-site inspection of this structure revealed that the mockup had sustained considerable damage over the years due to testing and frequent moves. The decision was therefore made by Essex to build a new mockup at no additional expense to MSFC.

The new mockup was constructed (Figure 2.2 and Appendix B) of a light-weight aluminum frame covered with the same materials used on the ST mockup, resulting in a realistic approximation of the flight laminated insulation blanket. New berthing pins were constructed using drawings of flight equipment as a guide. As a weight-saving measure, these devices were made of aluminum instead of stainless steel. One additional change from the old mockup was to make the new one 30.5 cm long, instead of 61.0 cm, to reduce loading of the Target Motion Simulator mounting base.

2.3 TASK 3 - FABRICATION AND INSTALLATION OF DOCKING DEVICE

2.3.1 Development of Docking Device Design

The original design specified under MSFC contract NAS8-33073 utilized a passive latch/active unlatch design driven by a pair of rotary solenoids. While the design was feasible, it was not deemed optimal and lacked several highly desirable characteristics, including active latching and a method of determining whether or not a target pin was indeed captured. During the initial design phase, a concept was developed which utilized sliding passive latches and motor-driven cams which were of such a geometry as to grasp and retract the berthing pin if it fell within the capture range (Figure 2.3). Back driving of the latch mechanism was avoided through the use of a worm-wheel drive train.

An informal Preliminary Design Review (PDR) was conducted on October 4, 1983 with Frank Vinz, Gobe Vic, Ed Guerin, and Essex

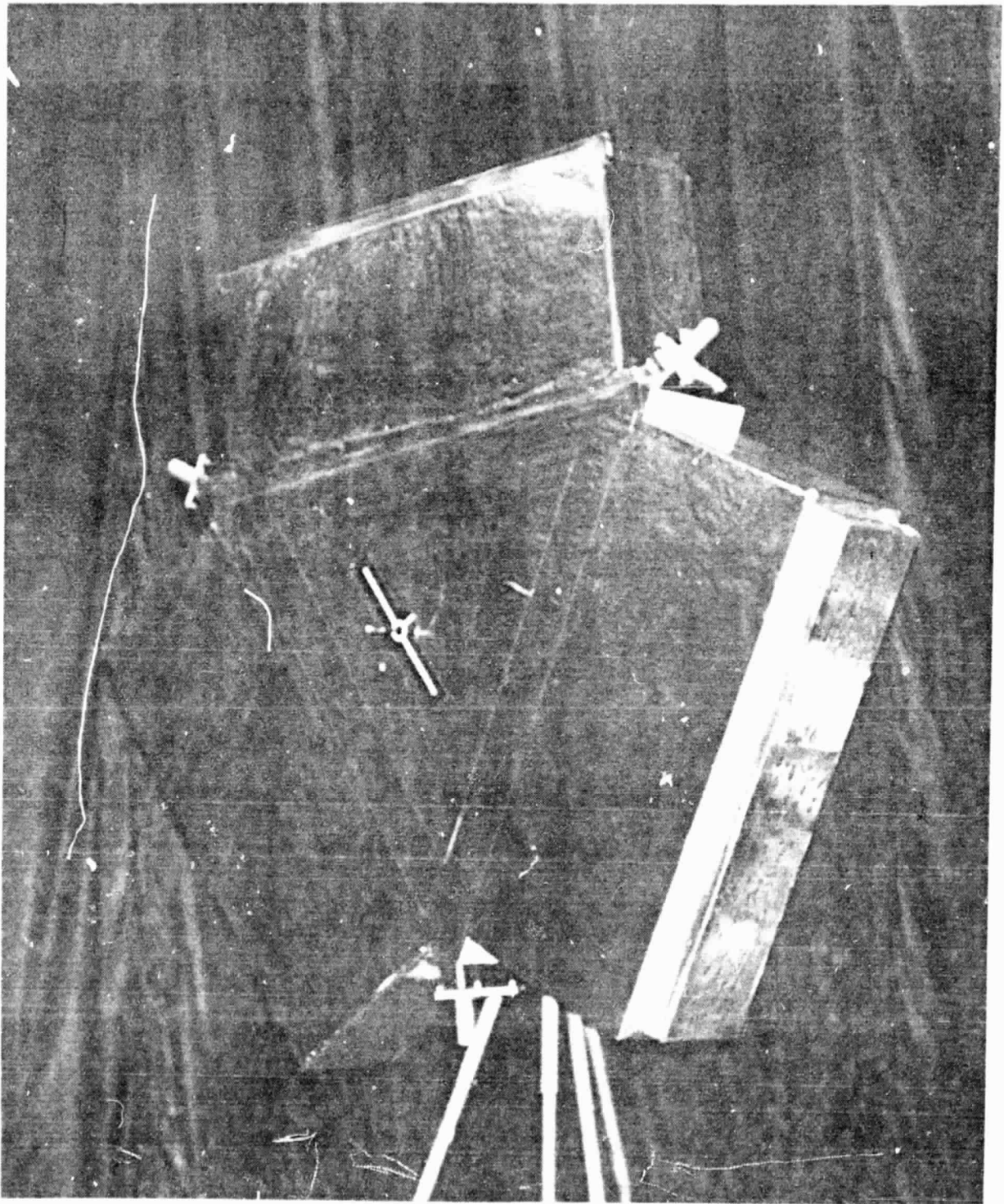


Figure 2.2: MMS Mockup Installed on Target Motion Simulator

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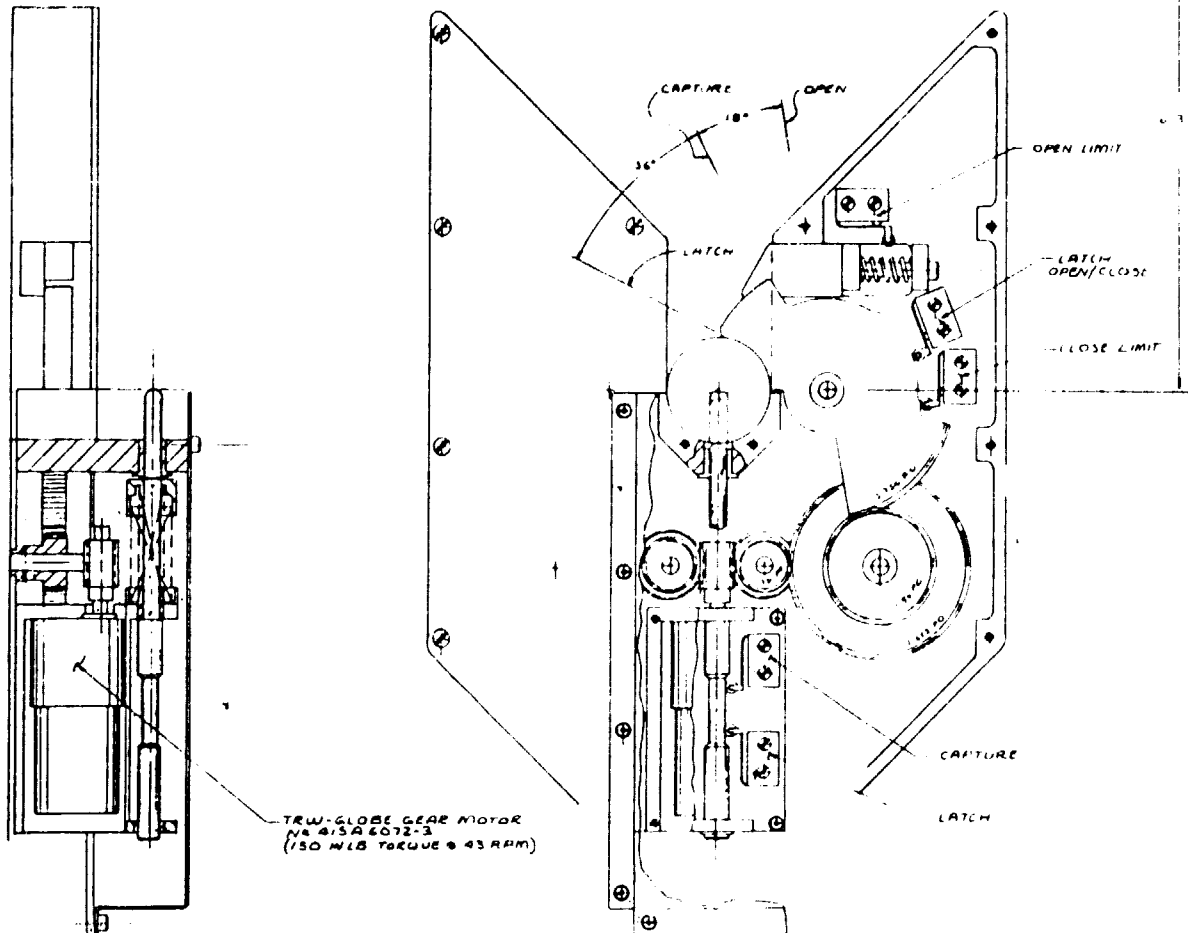


Figure 2.3: Interim Design of Docking Device



Corporation staff. The result of the PDR was approval of the general design concept with the following provisions:

- a. Switches and motor selected for use on the latch would be actual flight models or physically and functionally interchangeable with flight models.
- b. Hard latch indication will be via motor output, which requires the motor to survive repeated stalls.
- c. Trunnion position plunger should use a small spring for capture indication and a belleville spring for latch indication and preload.
- d. Change the soft capture plungers (sliding configuration) to a pivoting cam arrangement in order to reduce overall required capture force.
- e. Use bearing bushings made from Kel-F, Vespel, or similar material instead of bronze.
- f. The configuration of the latch should accommodate expected thermal deformation of the aft bulkhead of the Space Telescope.

The following actions were taken on the above recommendations.

- a. Switches were selected which had the same footprint as those used in flight equipment but were not hermetically sealed. Essex and MSFC engineering personnel agreed that no tangible benefit would be realized from the use of flight qualifiable switches. The drive motor was changed to one which is flight qualifiable switches. The drive motor was changed to one which is flight qualifiable and is a high grade aircraft-type gear motor manufactured by TRW-Globe.
- b. The use of motor output to indicate a hard latch condition was included in the new design. It can be monitored either through current drain by the motor or through a switch closure when a preset docking load is reached (see c below). The above motor and gear train configuration was selected so as not to exceed the manufacturers' recommended loads.
- c. The trunnion position plunger assembly was redesigned to allow a capture indication with a depressive force of 0.45 kg hard capture. Position plunger completely depressed requires a force of 22.7 kg (Figure 2.4 and dwg. no. 478001-Spring Plunger Assembly, Appendix C).

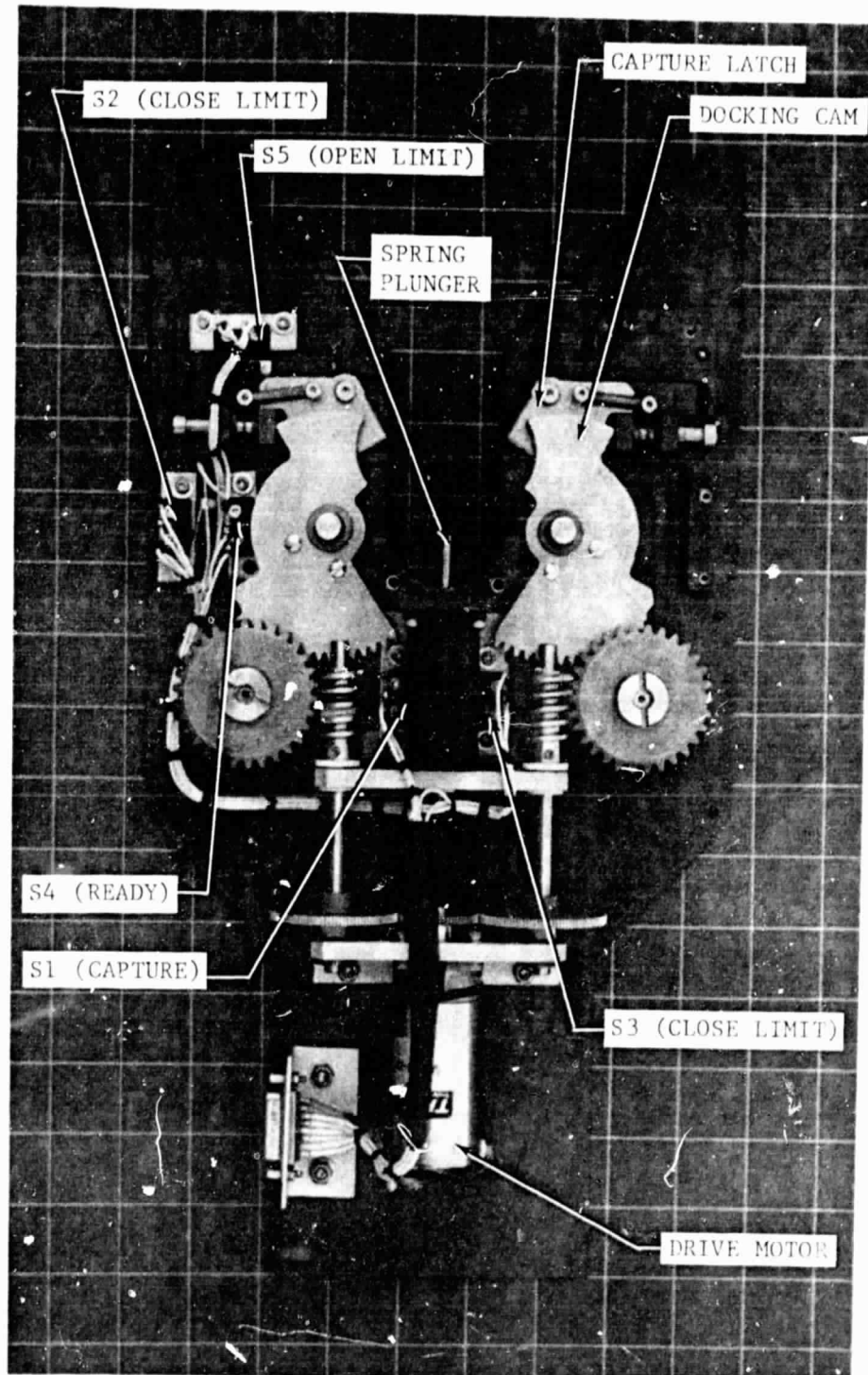


Figure 2.4: Final Configuration of Docking Device shown
with Cover Removed



- d. The soft capture plungers were changed to a pivoting cam arrangement as was recommended. This change resulted in a major impact on the geometry of the latch design and necessitated a reconfiguration of the drive train, gear geometry, trunnion position plunger, and location of indicator switches.
- e. The recommended use of Kel-F or Vespel bearing material was not followed after consultation with the COR when it was decided that these materials provide little benefit for non-flight mechanisms when compared with more cost-effective materials.
- f. The latch configuration was modified slightly to accommodate the expected 2.3 mm thermal deformation of the ST aft end. This value was obtained from MSFC engineering personnel.

2.3.2 Description of Fabricated Docking Device

The mechanical and electrical systems are detailed here to assist in analysis during integration tests and evaluations.

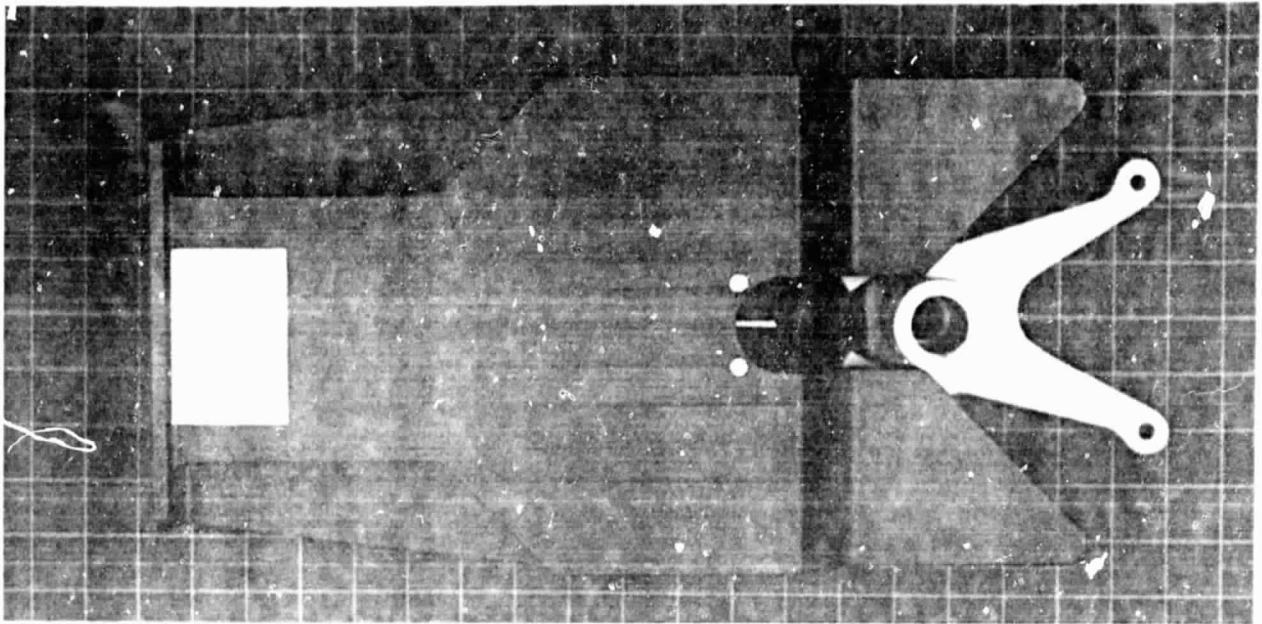
2.3.2.1 Mechanical Description

The final configuration of the docking device (Figure 2.4) utilizes a symmetrical pair of gear-driven cams which rotate through an arc of 60° to fully retract to a position inside the latch housing. The geometry of the latches is such that once a soft capture is made, the berthing pin is within grasp of the concave surface of the pair of cams. The total linear excursion is approximately 1.6 cm. The rotational force of the cams is obtained through a gear train which includes a worm/wheel combination. A separate gear train drives each cam; however, power is provided from a common D.C. gear motor. The reduction ratio of the gearing system (excluding that internal to the motor) is 108.89:1 for each side which, when coupled with the output of the TRW Globe model 5A2313-21 gear motor, gives a theoretical nominal output torque for each cam of 490 Ncm and a theoretical stall torque of 3006 Ncm. With both cams assumed to have equal contact with a berthing pin, this would result in a nominal total docking force of 257.2 N and a limit of 1577.9 N. Because of the trunnion position plunger's opposing force of approximately 222.4 N, this would result in a total theoretical docked force of 1355.5 N. Figure 2.5 illustrates the docking sequence using a berthing pin from the MMS mockup.

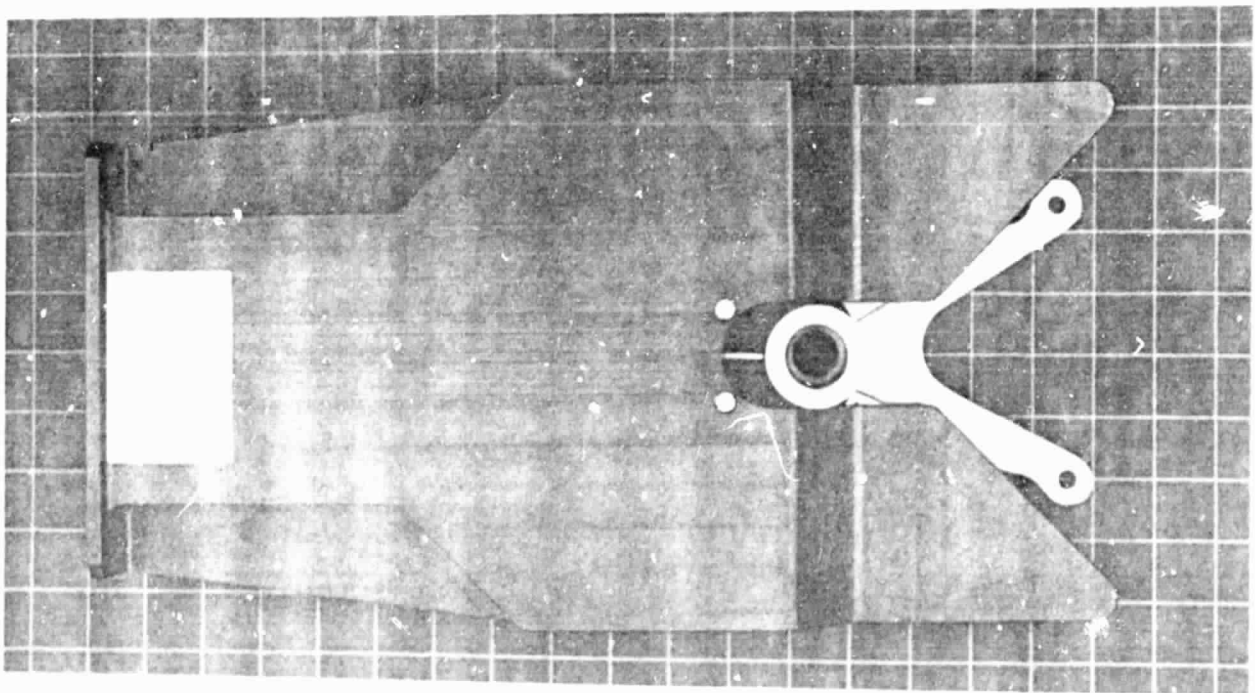
An interim design utilized a differential gear assembly which was meant to equalize the rotational force between the two docking cams and also served to slow the rotational velocity of the cams. This design worked; however, positional synchronization of the two cams proved difficult and it was decided that a straight gear drive would be utilized.

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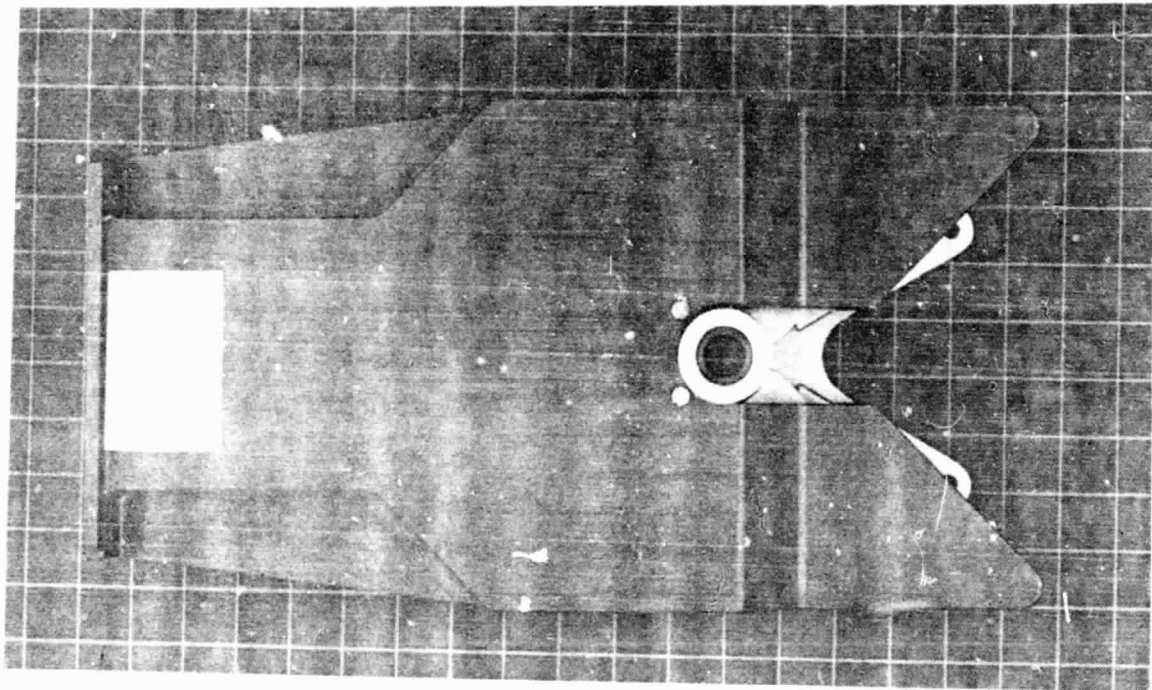
2.5a Approach of Berthing Pin



2.5b Berthing Pin Captured

Figure 2.5: Docking Device Capture and Docking Sequence

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2.5c Berthing Pin Fully Docked



2.3.2.2 Electrical Description

The electric drive motor (TRW Globe model 5A2313-21) was designed for use with a 12 VDC power source. Reversal of polarity of the DC voltage results in a reversal of motor direction. Nominal current required (no load condition) is .50 amperes. Rated load (docking) is 1.2 amperes, and fully loaded (stall) is 5.1 amperes. These values were furnished by the manufacturer and may vary as a function of brush drop, field distortion, power supply, wiring, mechanical friction, etc., and should be used as guidelines in the design of control circuitry.

Each docking device is equipped with five micro switches (Figure 2.5 above) which may be wired in one of several control and/or indicator function modes. Provisions are made for the addition of three more switches for redundancy purposes. Two of the switches (S1 and S4) are used for indication purposes while the other three (S2, S3, and S5) serve as limit switches. The switch circuitry and the motor drive circuitry are electrically separated to allow the drive motor to be controlled either through a process control system or through direct limiting by utilizing the switches and diodes in a series configuration.

2.3.3 Proposed Modifications to the Docking Device

Bench testing of the three docking devices resulted in satisfactory performance of the units. No formal stress analysis was performed. It is anticipated that docking loads observed during testing may reveal deficiencies in the strength of certain mechanical components. The design itself can easily be adapted to accept higher loads with minimal impact on the geometry of the mechanism.

Prior to completion of assembly, informal docking simulations were performed using the exterior portions of the docking devices equipped with position plungers mounted on the TOM-B. These tests confirmed the effectiveness of the geometry of the docking devices and mounting structure and served as a partial proof test of the resistance of the assembly to simulated docking loads.

2.4 TASK 4 - IDENTIFICATION OF TEST REQUIREMENTS FOR THE THREE CLAW DOCKING DEVICE

The experimental and laboratory criteria for successful testing of rendezvous and docking using the three claw docking device are outlined below.

2.4.1 Test Requirements Objectives

In order to demonstrate remote docking capabilities with targets like the Multimission Modular Spacecraft and the Hubble Space Telescope, operators will be required to position and orient the Teleoperator Mobility Base with respect to the target and maintain orientation while translating to the target. The docking operation will need to be

carried out under various lighting conditions, video system configurations, closure rates and geometries, and docking hardware concepts. The identification of the types of parameters and the levels of parameters, along with the appropriate dependent measures to be collected, are the objectives of this test requirements section.

2.4.2 Operator Requirements

The test requirements concerning the remote system operators center on the representative nature of the operator pool. The operators should reflect the male and female operator population, have appropriate technical background and experience, be free of psychomotor and visual anomalies, and be adequately rehearsed on remote systems tasks to eliminate effects of learning from research findings. Other requirements include:

- o Even mix of male and female subjects,
- o Representative anthropometry,
- o Visual acuity and stereopsis tested through the Orthorator exam, color vision tested through the Pseudo Isochromatic Plate Tests,
- o Psychomotor coordination and skills tested through the Purdue Pegboard Test,
- o Translation and rotation hand controller remote system experience which measures baseline variation of less than 5% on fixed performance criteria,
- o Familiarity with operations from the Reconfigurable Work Station,
- o Familiarity with activation and deactivation of the docking mechanism,
- o Prepared operating instructions for all operators,
- o Fixed operating periods for task performance for all subjects.

2.4.3 TOM-B Requirements

The test requirements for the motion base are concerned primarily with preparation and calibration of the TOM-B prior to operations to ensure that all of the control variables are fixed and that the unit operates consistent with the design criteria. The test requirements to be met are:

- o Preload thruster and air pad air tanks to 3000 psi or another prespecified level below 3000 psi, if required,



- o Verify activation of each thruster,
- o Verify and record the on-board electrical power status,
- o Verify bi-directional motor drives for each motor driven axis,
- o Verify CTU operations and transmitter/receiver operations,
- o Verify operation of on-board experimental equipment such as lights, cameras, pan/tilt units, docking devices, etc.,
- o Verify correct software model and correct physical configuration of plena which reflect the software model.

2.4.4 Target Requirements

The disposition of the targets used during experiments will be test specific in terms of geometry, lighting, docking targets, etc., but the general requirements for every target used will include the following:

- o For fixed targets, verify that the target is secured to the target mount and that all bolts, nuts and break away structures are in place. Verify that the target mount is securely attached to the floor or other pedestal.
- o For moveable targets, verify that the target is securely mated to the standard mounting plate and that the appropriate counter weights are securely installed. Verify the bi-directional motor drives for each axis requiring motion. For targets mounted on the target motion system, verify that the low pressure air umbilical is properly connected and that the air flow regulator is correctly set.
- o Verify that experiment peculiar subsystems are correctly mounted and set. These would include docking targets, docking probes, target geometries and positions, antennas and solar arrays.
- o Verify and calibrate any on-board data recording devices.

2.4.5 Environmental Requirements

The condition of the laboratory environment in which experiments are conducted is critical to the validity and reliability of the experimental data. Those variables which require conditioning and recording are:

- o Air Flow - all air handling equipment should be turned off to prevent air currents from confounding the experimental findings.

- o Ambient Lighting - all lighting systems not required as part of the experimental design should be turned off.
- o Airbearing Epoxy Floor - this should be cleaned with isopropol alcohol and a clean mop prior to each test run.
- o Access - the laboratory spaces should be secured and signs posted stating that testing is being conducted and that entry is not permitted. Access to the operator's control room must also be restricted.
- o Communications - verify the communications network, including experimenters' communications and isolation of the operator's communication during tests.

2.4.6 Data Requirements

For each of the experiments run in the laboratory, the data requirements are the most significant factor to consider. The independent, dependent and control measures must be carefully identified prior to actually running any experiments. The use of these data, in the form of a multivariate statistical analysis, must also be defined prior to data collection. This will assure that the type of data being collected and the analyses are appropriate to one another and will yield useful design or engineering data at the conclusion of the experimental run. The minimal dependent data requirements will be of the form:

- o Performance time - time to complete whole and specific part tasks.
- o Performance error - deviations from prespecified performance criteria.
- o Resources expenditure - the amount of expendable resources used during a particular task.

There are variations on each of these measures such as direction and amplitude of errors, temporal and spatial distributions, etc., which would be appropriate to specific evaluations.



3.0 CONCLUSIONS AND RECOMMENDATIONS

All contract tasks were performed as planned and the contract end items, including three claw docking device, ST mockup and MMS mockup, were delivered and installed in MSFC Building 4619.

This hardware provides the Teleoperator and Robotics Evaluation Facility with the capability to simulate docking with observatory class spacecraft (i.e. ST) and MMS class spacecraft. These two classes of freeflyers represent the majority of spacecraft anticipated in the 1985-2000 timeframe and will likely be the object of the majority of docking studies.

However, neither the ST or MMS mockups have the capability to simulate continuous, controlled 360° roll which the spin stabilized spacecraft will require. To more accurately duplicate the docking tasks for these spacecraft, this roll capability should be developed as preliminary docking studies are performed on the current mockups.



APPENDIX A: Drawings of Space Telescope Mockup

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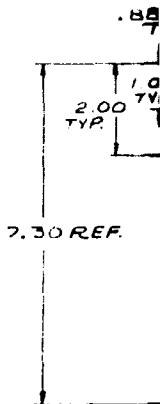
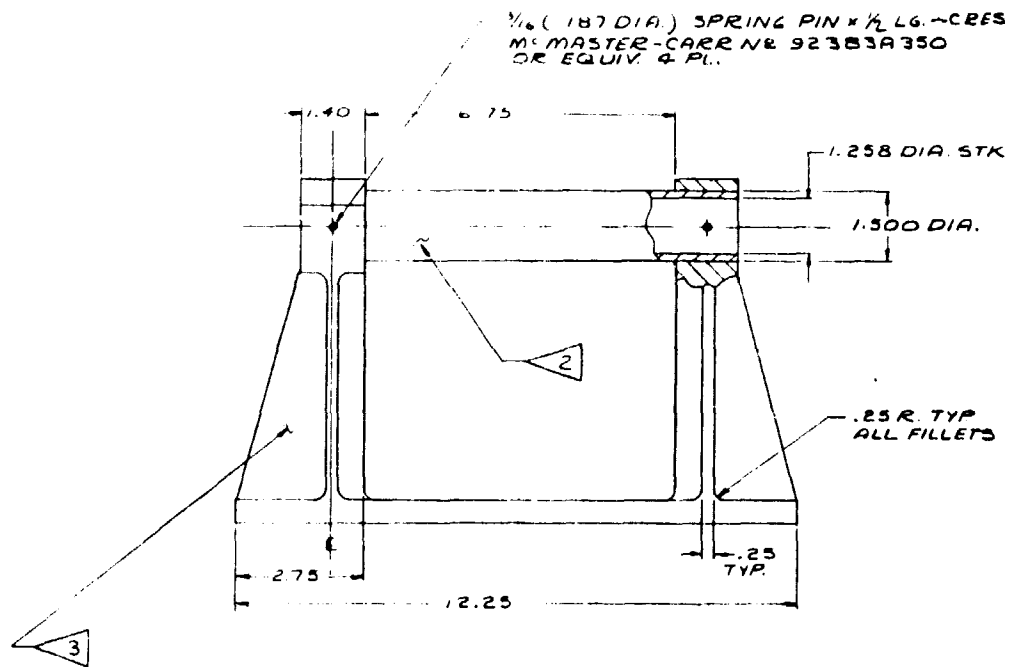
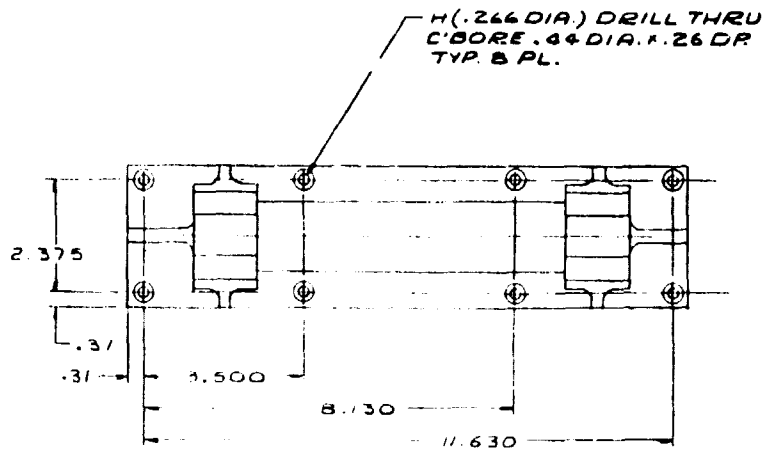
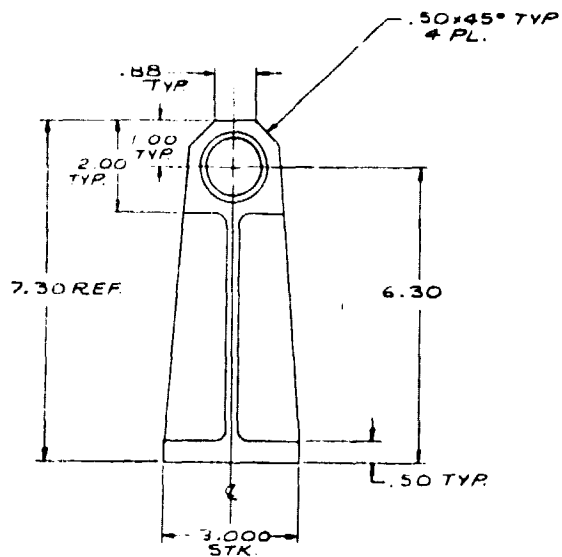


FIGURE 1

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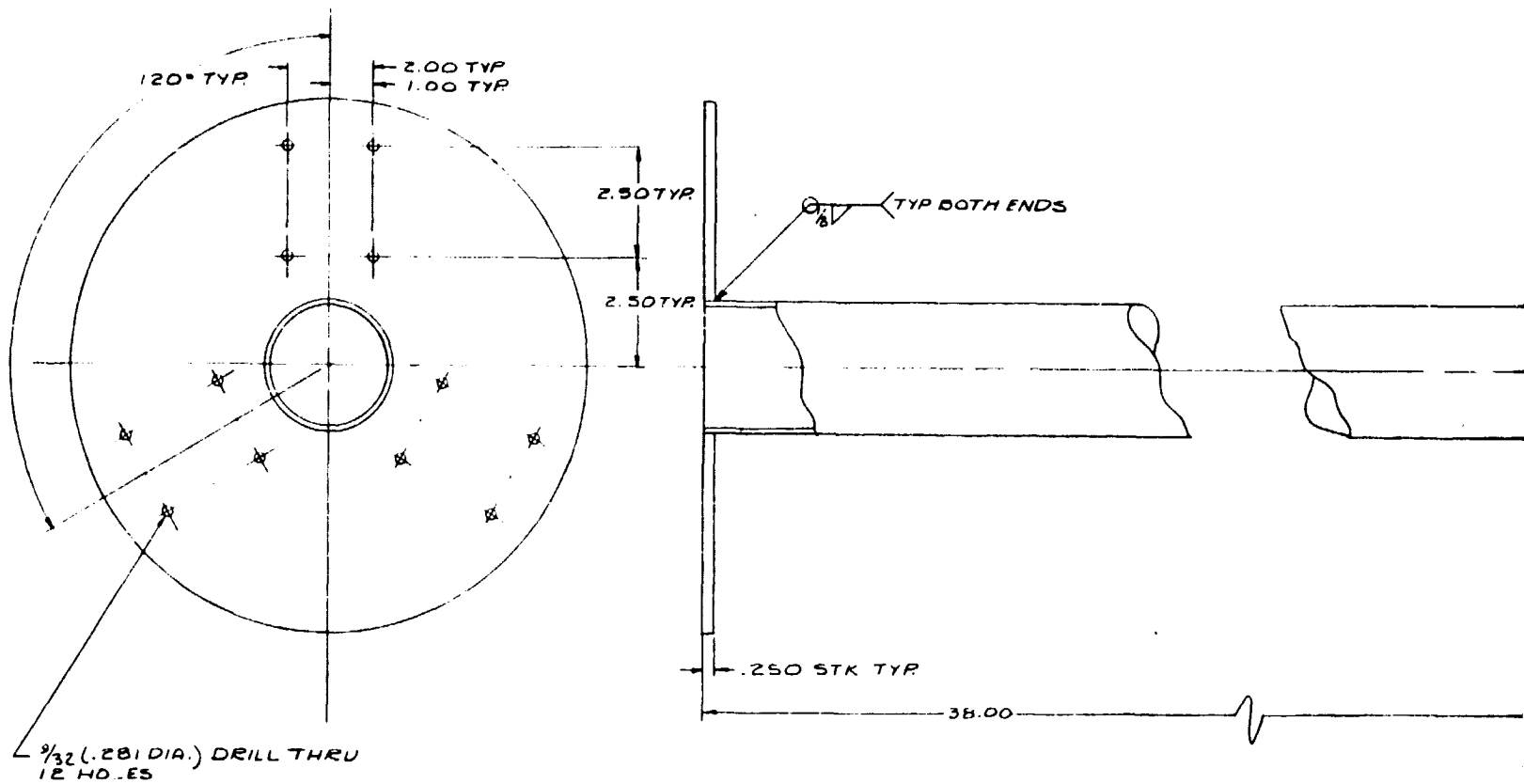
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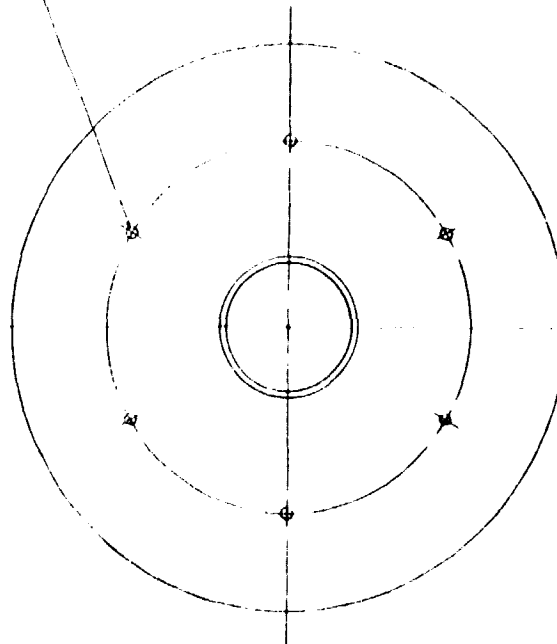
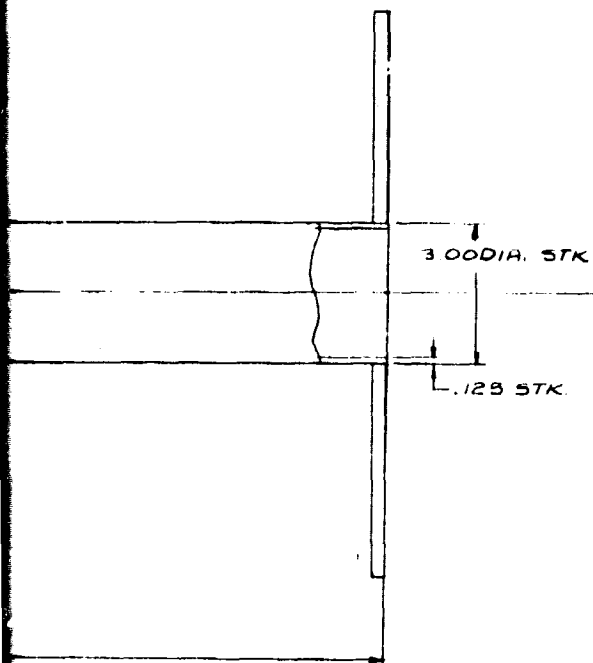
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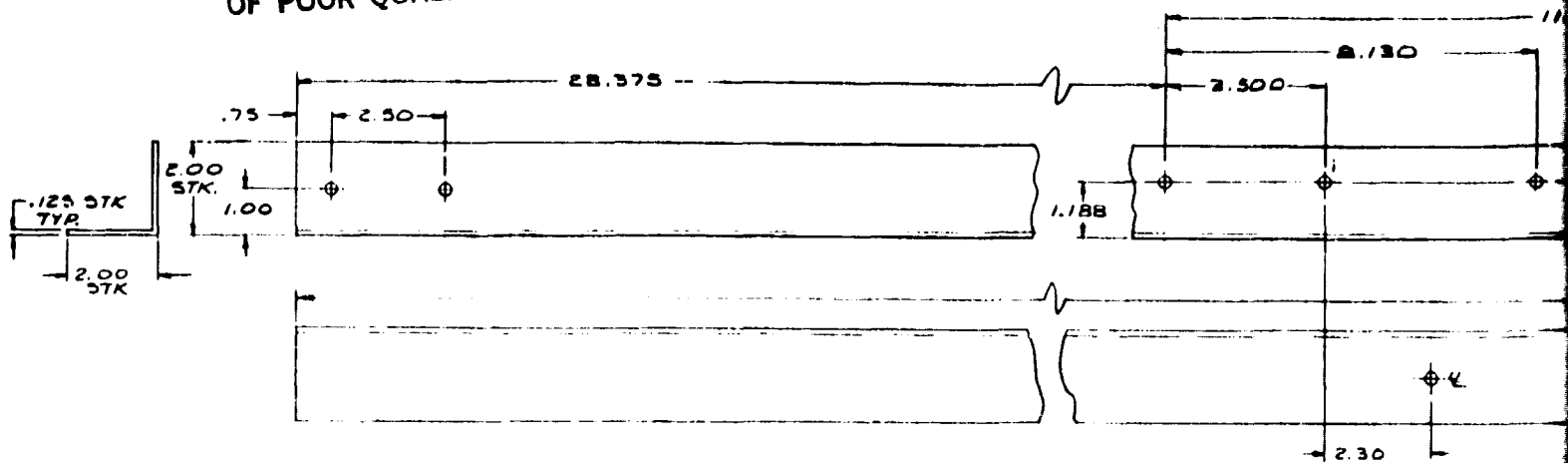
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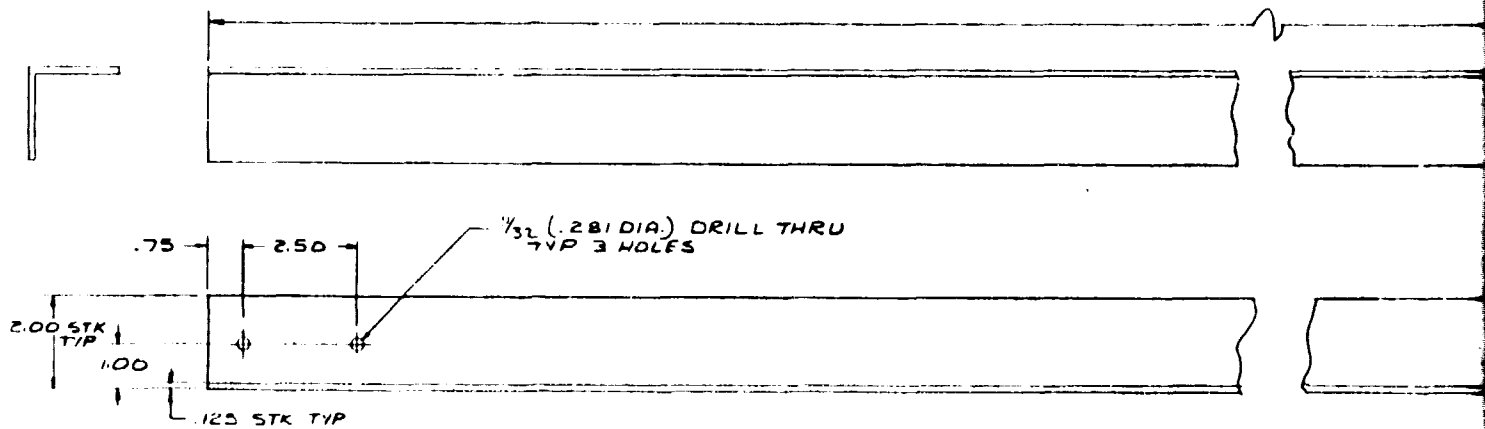
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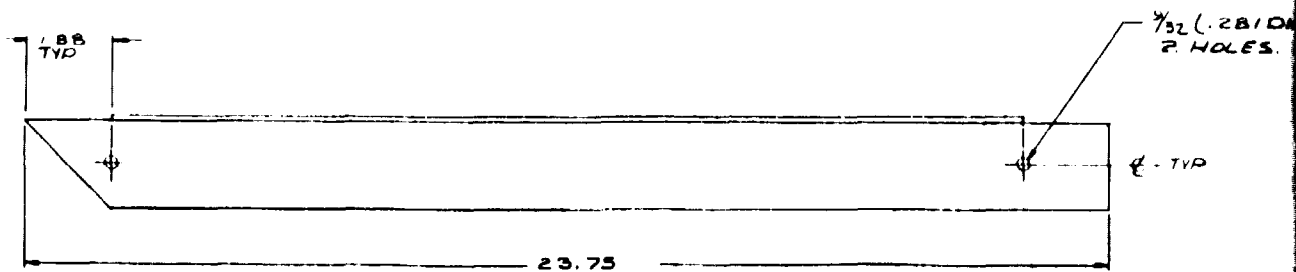
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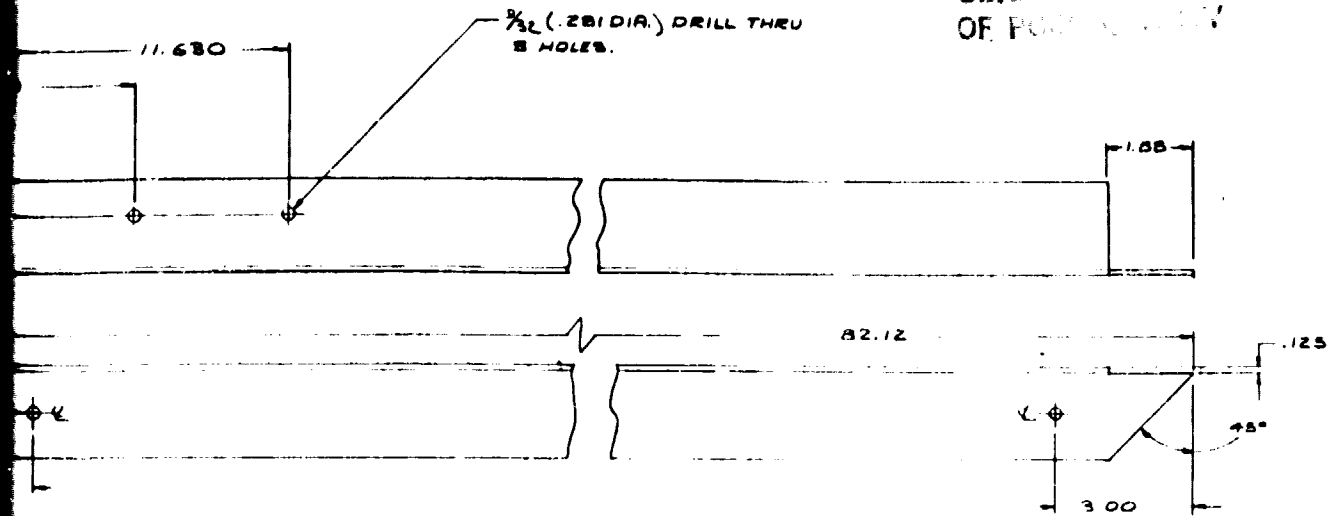
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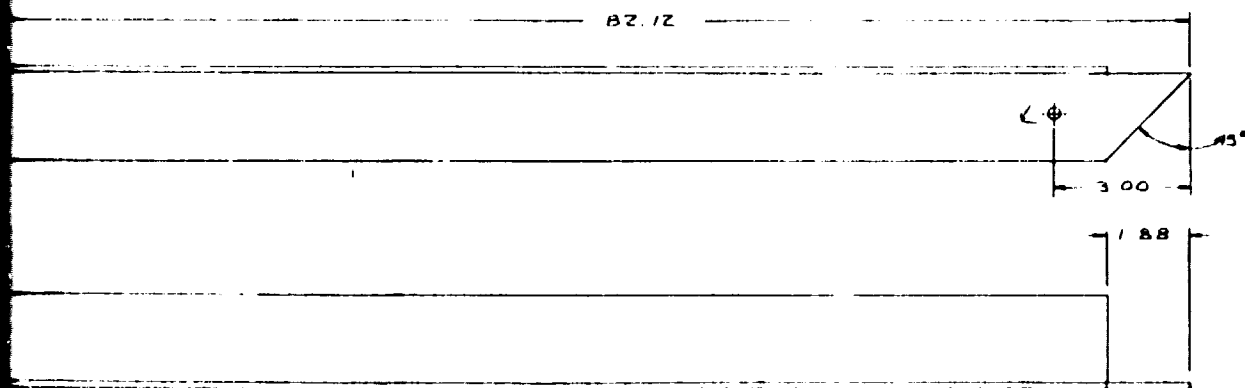
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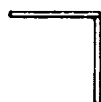
MEMBER
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$\frac{3}{32}$ (.281 DIA.) DRILL THRU
2 HOLES

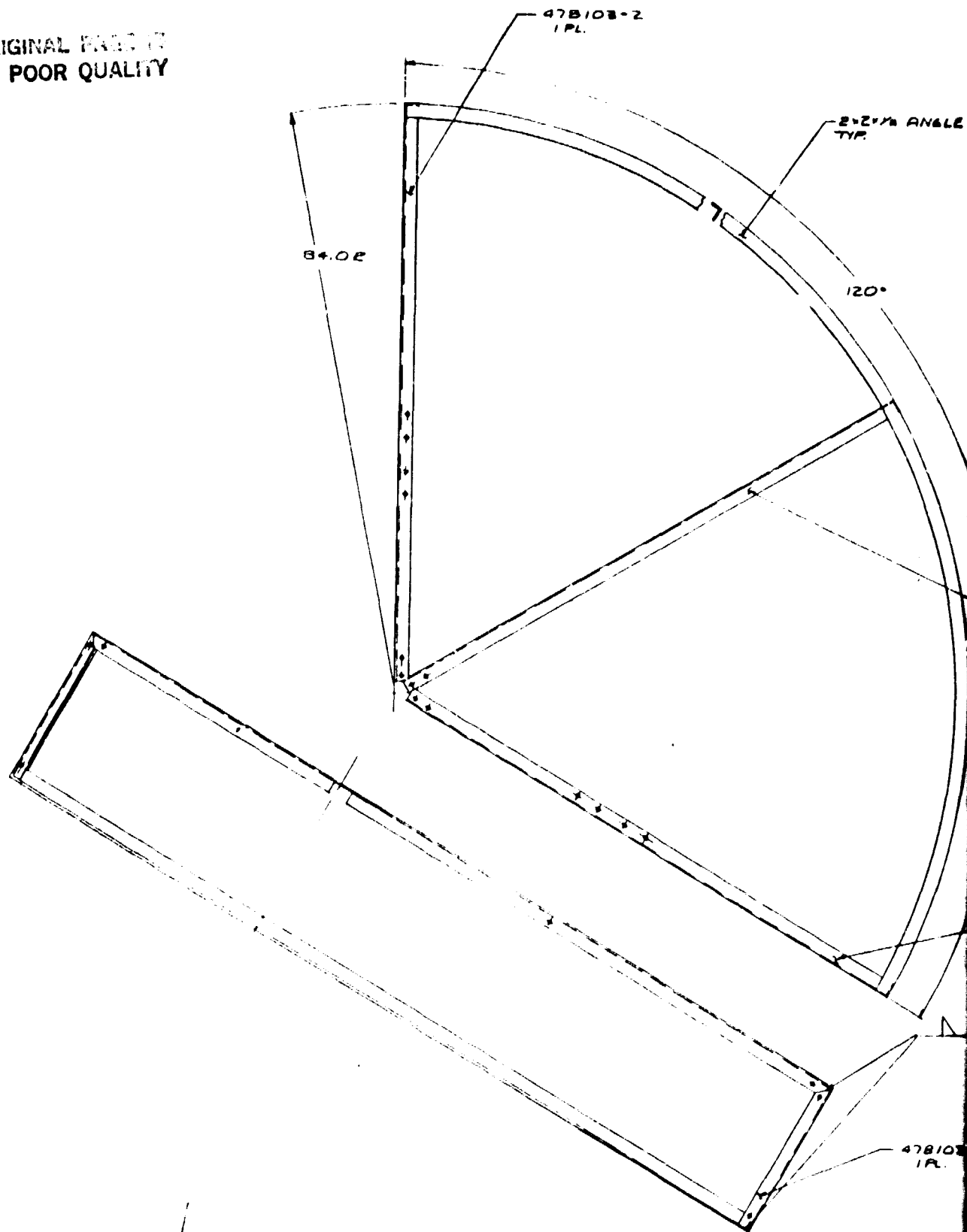
TYP



2 FOLDOUT FRAME

UNLESS OTHERWISE SPECIFIED		ESSEX		MONTROUSE FACILITY 1000 S. MONTROUSE PARKWAY MONTROUSE, AL 36051		DESIGNED BY TJJD/SMAD	
DIMENSIONS ARE IN INCHES						DATE MAR 21-92	
TOLERANCE ON						APPROVED	
FRACTIONS		DECIMALS		ANGLES		CONTRACT 00078	
		.005		.005		DR. DMS NUMBER 078103	
MATERIAL: AL ALLOY ANGLE 2x2x1/8						SCALE 1/2	
FINISH PROTECTIVE FINISH NONE						SHEET 07	
STRUCTURAL MEMBERS~ ST. MOCKUP							

ORIGINAL PAGE IS
OF POOR QUALITY



FOLDOUT FRAME

ORIGINAL OF POOR QUALITY

2 1/2 ANGLE


478103-4
Z PL.

478103-3
IPL

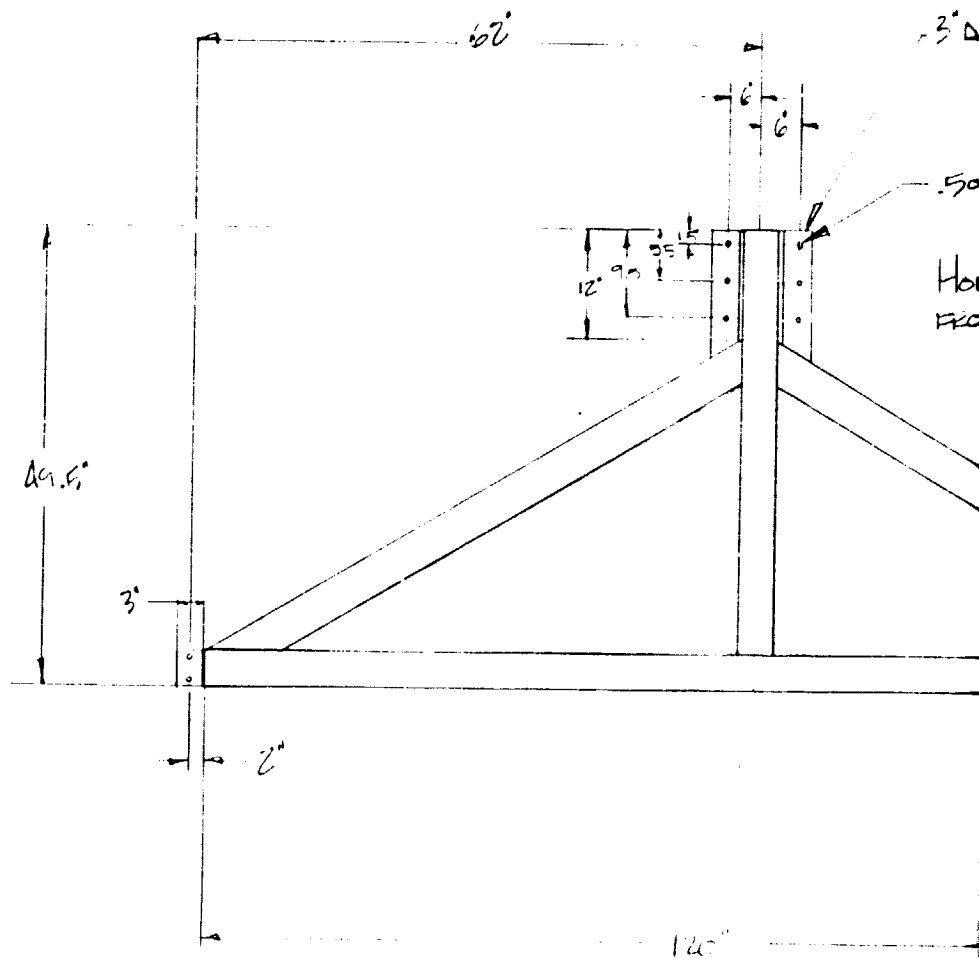
478103-1
IPL

473103-5
1A.

2 FOLDOUT FRAME

UNLESS OTHERWISE SPECIFIED			 HUNTSVILLE FACILITY 2222 S. MEMORIAL PARKWAY HUNTSVILLE AL 35891		DRAWN BY 0064HEAD	
DIMENSIONS ARE IN INCHES			SECTION ASSY ~ S.T. MOCKUP		DATE 5-22-82	
TOLERANCE ON FRACTIONS					APPROVED	
DECIMALS ANGLES					CONTRACT	
MATERIAL AL. ALLOY			DRAWING NUMBER 478104		SHEET OF	
FINAL PROTECTIVE FINISH NONE			SCALE 1/10			

ORIGINAL 1
OF POOR QUALITY



FOLDOUT FRAME

COPIED
OF 1



-3" ANGLE

-500 LBS THRU
10 PLACES

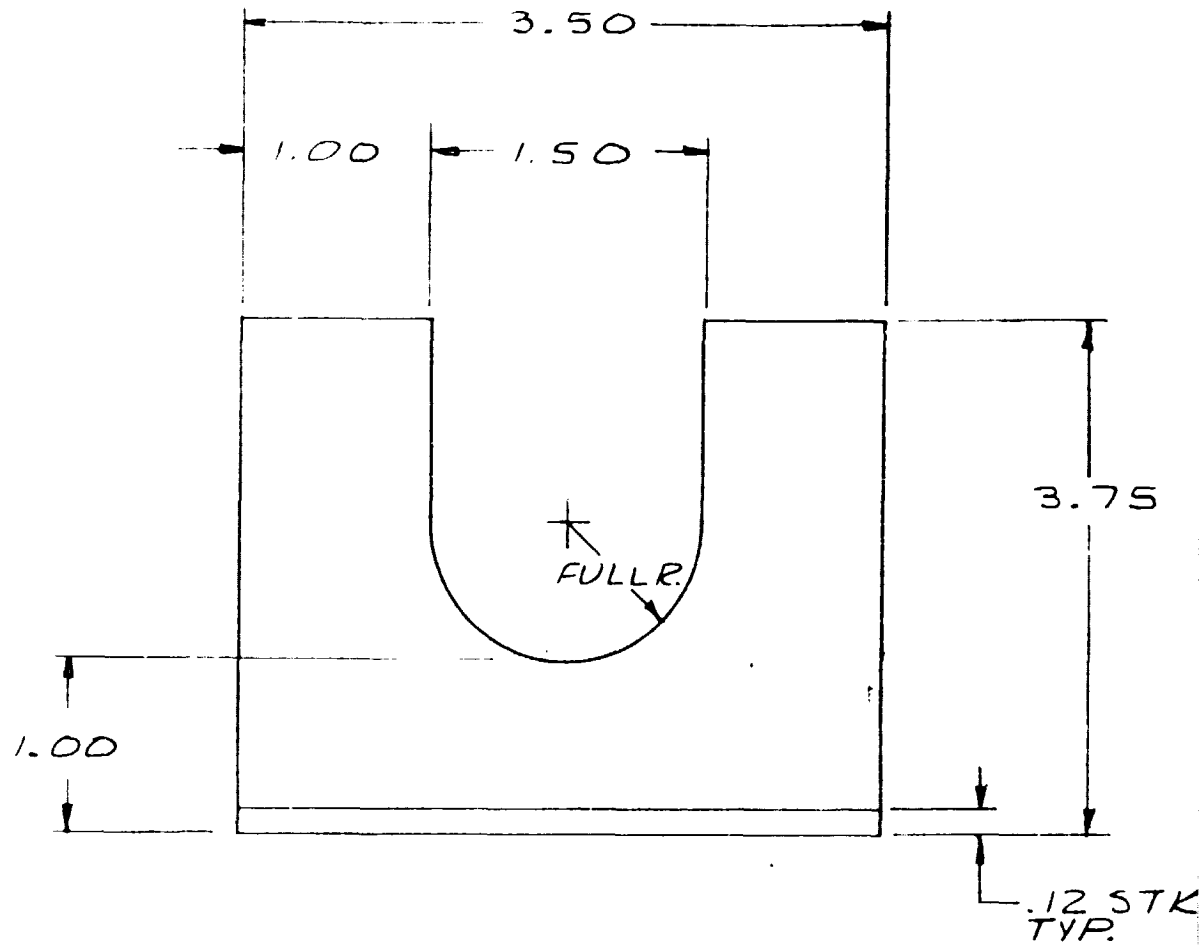
HOLES TO BE TRANSFERRED
FROM THIS FRAME.

-3" ANGLE

2 FOLDOUT FRAME

UNLESS OTHERWISE SPECIFIED			ESSEX		MUNTSVILLE FACILITY 8888 S. MEMORIAL PARKWAY MUNTSVILLE, AL 36051		DRAWN BY 
DIMENSIONS ARE IN INCHES TOLERANCE ON FRACTIONS DECIMALS ANGLES ±.005 ±.005 ±.005			ST SUPPORT FRAME FOOT PRINT		DATE 10/1/85		APPROVED 
MATERIAL STEEL					CONTRACT 428105		DRAWING NUMBER 428105
FINAL PROTECTIVE FINISH PAINT					SCALE 1" = 1'-0"		SHEET 1 OF 1

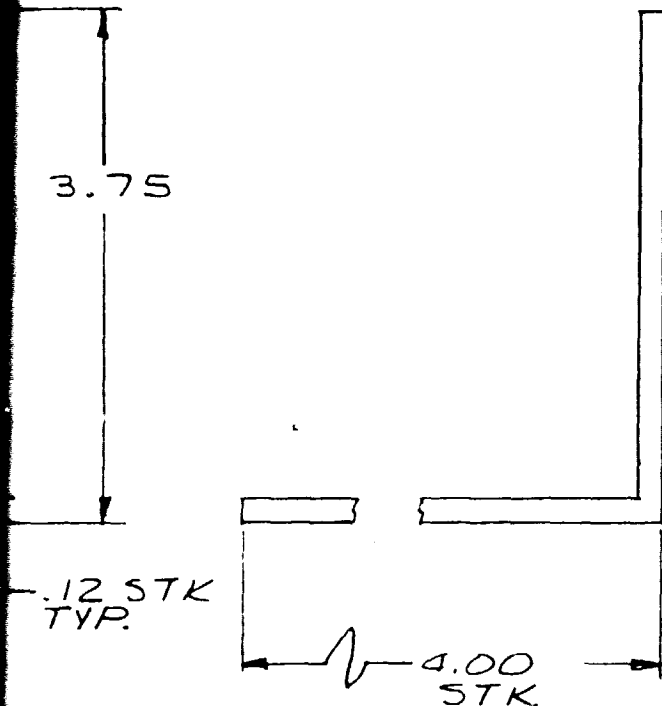
ORIGINAL PAGE IS
OF POOR QUALITY



FOLDOUT FRAME

UNLESS OTHERWISE SPECIFIED	
DIMENSIONS ARE IN INCHES	
TOLERANCE ON FRACTIONS	
~	XX
	XX
MATERIAL	
ALUM. PLATE	
FINAL PROTECTIVE FINISH	
NONE	

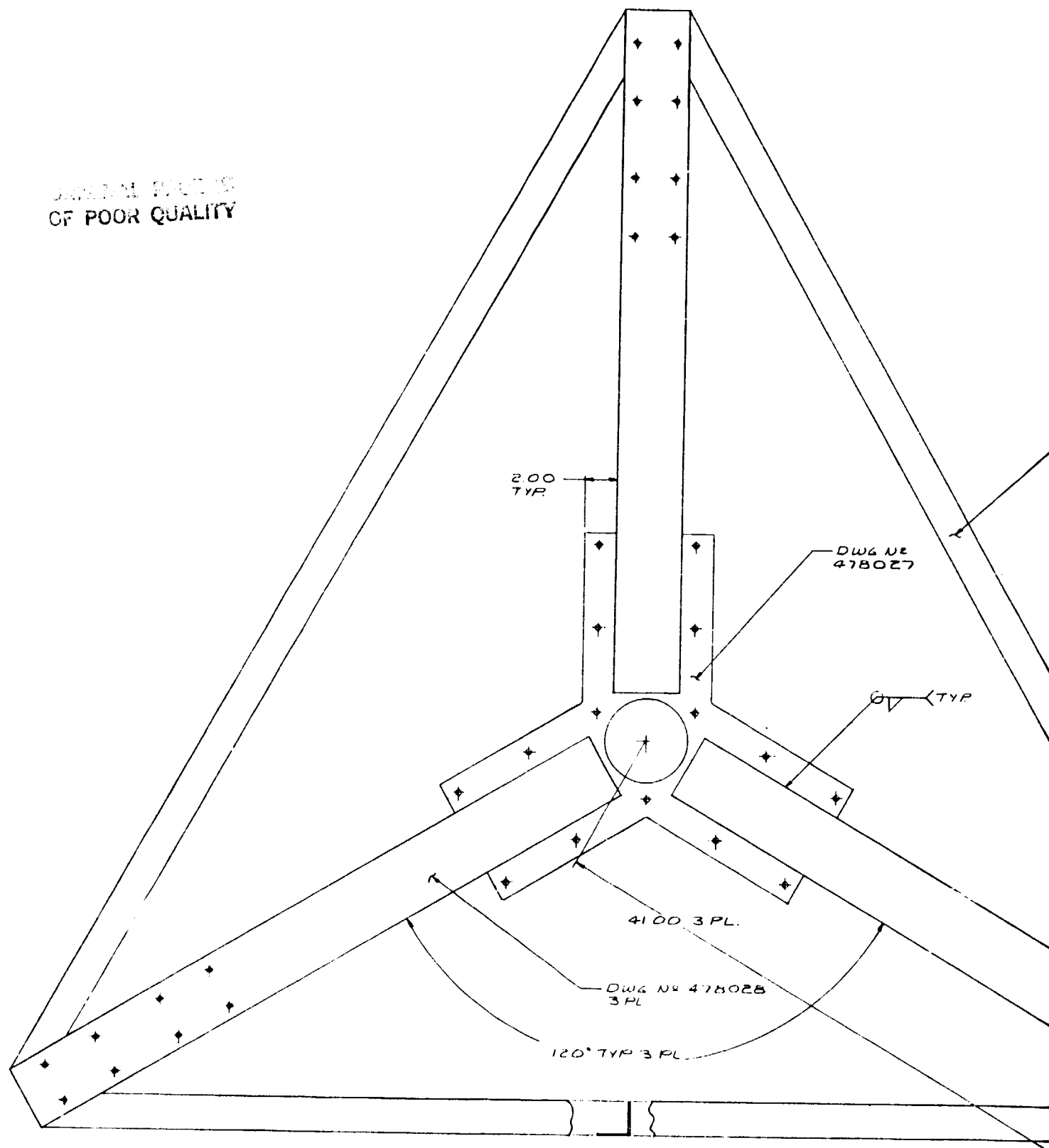
COPIED FROM
OF FOUR QUARTY



2 FOLDOUT FRAME

UNLESS OTHERWISE SPECIFIED					HUNTSVILLE FACILITY 3322 S. MEMORIAL PARKWAY HUNTSVILLE, AL. 35801		DRAWN BY LOUGHEAD	
DIMENSIONS ARE IN INCHES TOLERANCE ON FRACTIONS DECIMALS ANGLES ~ XX ± .06 ~ XXX ± ~			HANDRAIL BKT ~ ST. MOCKUP		DATE 5-21-82		APPROVED 	
MATERIAL ALUM. ALLOY					CONTRACT 00478			
FINAL PROTECTIVE FINISH NONE					DRAWING NUMBER 478106			
SCALE 1-1					SHEET OF			

ORIGINAL PAGES
OF POOR QUALITY



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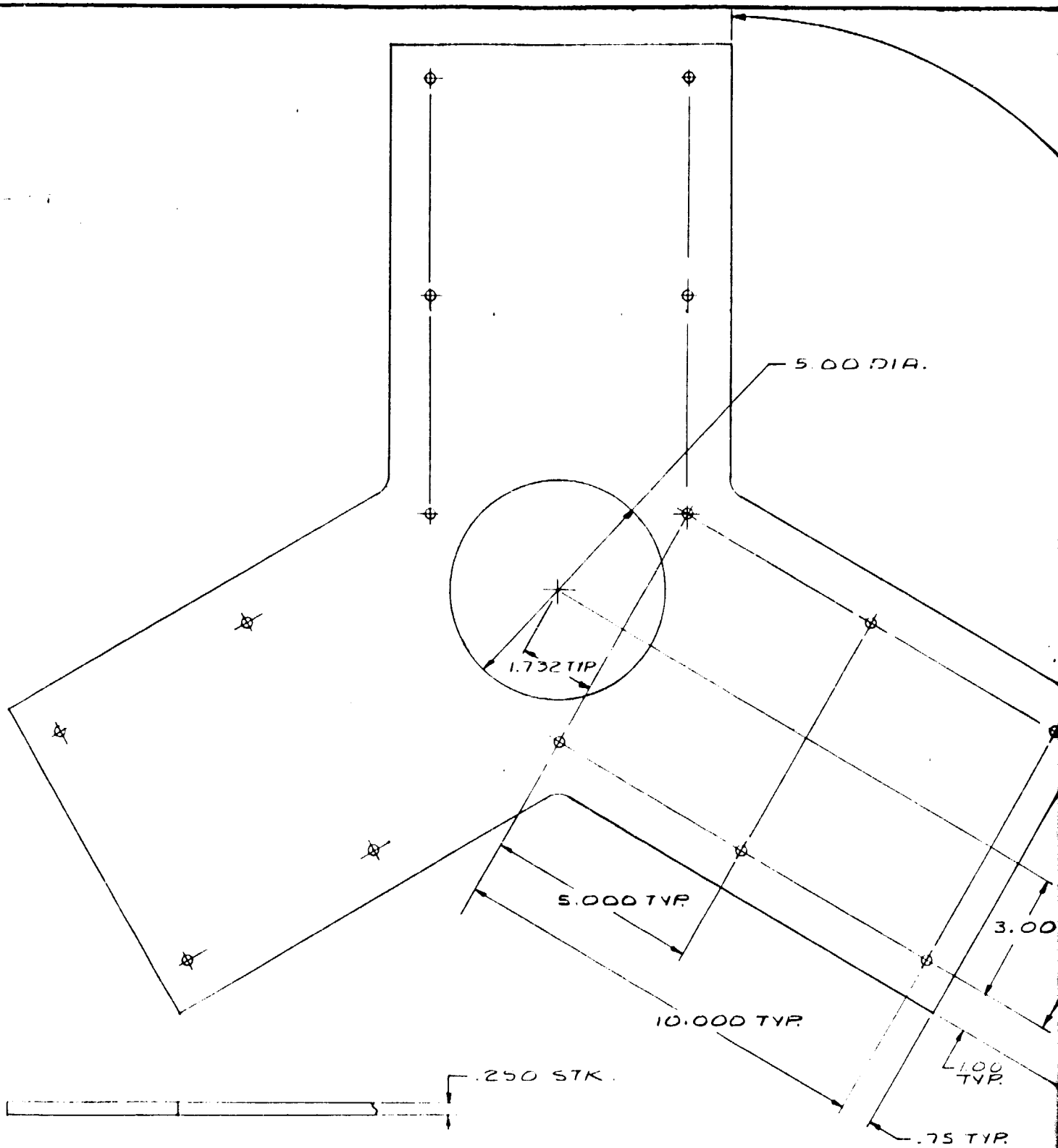
ESSEX
GREENVILLE, S.C.

DWG. NO. 478029
3 PL.

(TYP

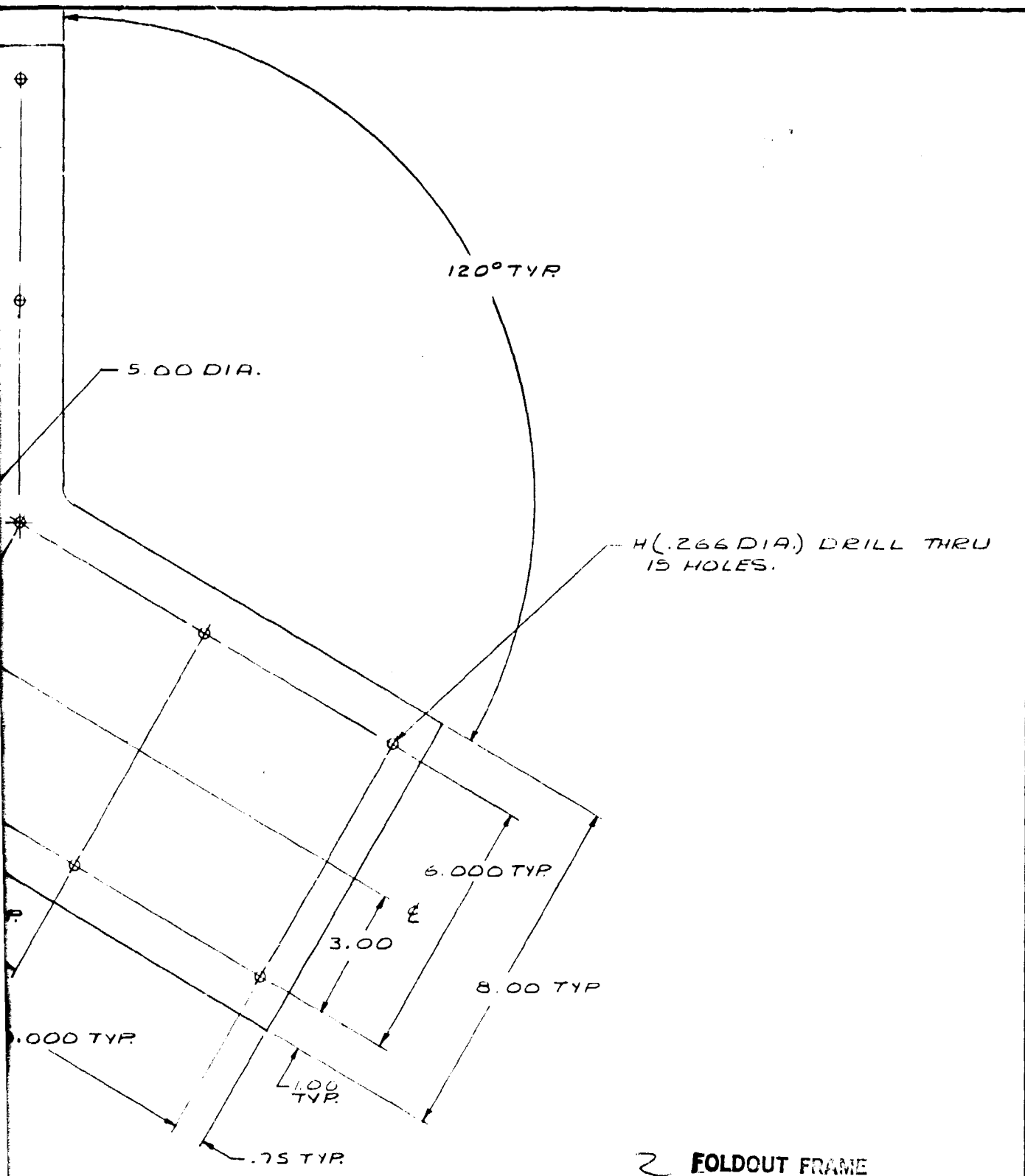
2 FOLDOUT FRAME

UNLESS OTHERWISE SPECIFIED		ESSEX GREENVILLE, S.C. GREENVILLE, S.C.	DRAWN BY JAS. J. FAD
DIMENSIONS ARE IN INCHES TOLERANCES ON FRACTIONS DECIMALS ANGLES XXX .030 XXX			BY B 21-02
MATERIAL NONE			APPROVED
FINAL PROTECTIVE FINISH NONE			SCALE 1/2
GERTHING PIN SUPPORT ASSY			CONTRACT 0678
			DRAWING NUMBER 478030
			SHEET OF



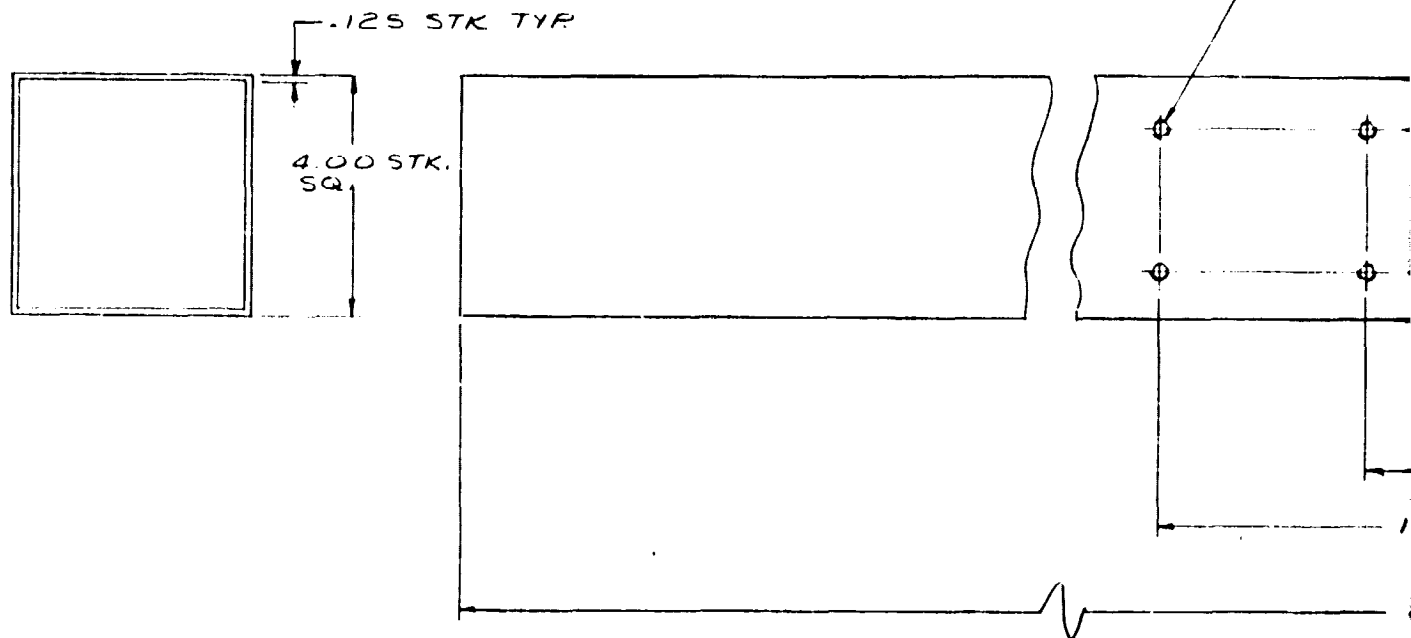
FOLDOUT FRAME

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCE ON DIMENSIONS
FRACTIONS
~
MATERIAL
AL AL
FINAL PROTECTIVE COATING
~



UNLESS OTHERWISE SPECIFIED		ESSEX HUNTSVILLE FACILITY 8322 S MEMORIAL PARKWAY HUNTSVILLE AL 35891	DRAWN BY LOUGHEAD
DIMENSIONS ARE IN INCHES TOLERANCE ON FRACTIONS DECIMALS ANGLES \sim $\pm .015$ $15'$ $\pm .003$			DATE AUG 26-82
MATERIAL AL ALLOY			APPROVED
FINAL PROTECTIVE FINISH \sim			CONTRACT 00478
SCALE $1/2$			DRAWING NUMBER 478027
			SHEET 01

ORIGINAL PL. 177
OF POOR QUALITY

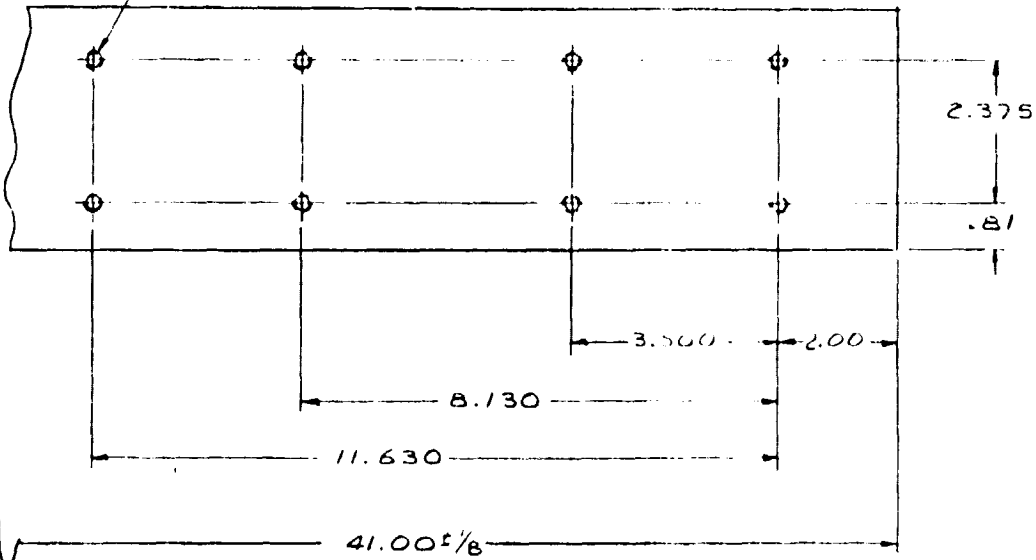


FOLDOUT FRAME

UNLESS OTHERWISE SPECIFIED	
DIMENSIONS ARE IN INCHES	
TOLERANCE ON DIMENSIONS	
FRACTIONS	DECIMALS
~	~
MATERIAL	
ALUM.	
FINAL PROTECTIVE FINISH	
~	

0.0000
0.0000

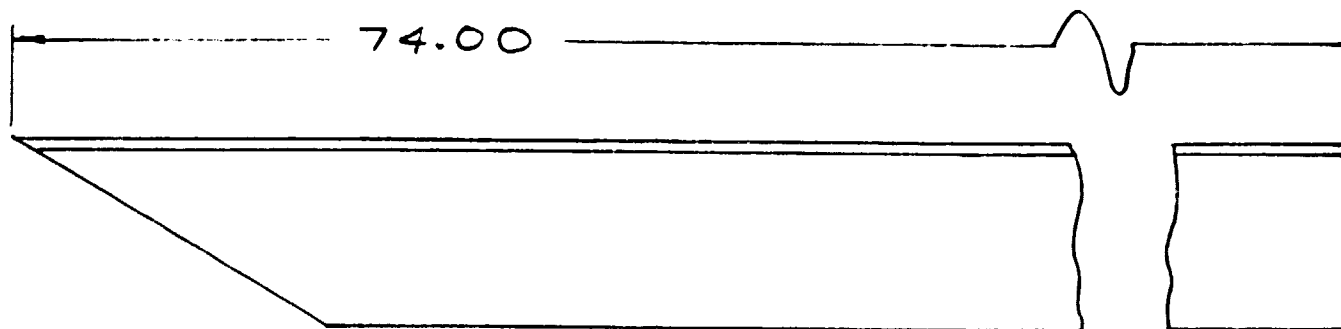
1/4-20 NC SWAGED THREADED INSERT
3/8 LG. TYP B PL.



2 FOLDOUT FRAME

UNLESS OTHERWISE SPECIFIED		<div style="border: 1px solid black; padding: 2px; display: inline-block;">ESSEX</div> HUNTSVILLE FACILITY 3307 S MEMORIAL PARKWAY HUNTSVILLE AL 35891	DRAWN BY LOUGHEAD
DIMENSIONS ARE IN INCHES TOLERANCE ON FRACTIONS DECIMALS ANGLES ~ .015 ~ ~ .005 ~			DATE AUG 20 '84
MATERIAL ALUM. ALLOY			APPROVED CONTRACT 0047B
FINAL PROTECTIVE FINISH ~	SCALE 1/2		DRAWING NUMBER 478028
			SHEET OF

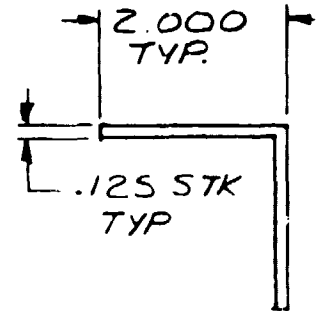
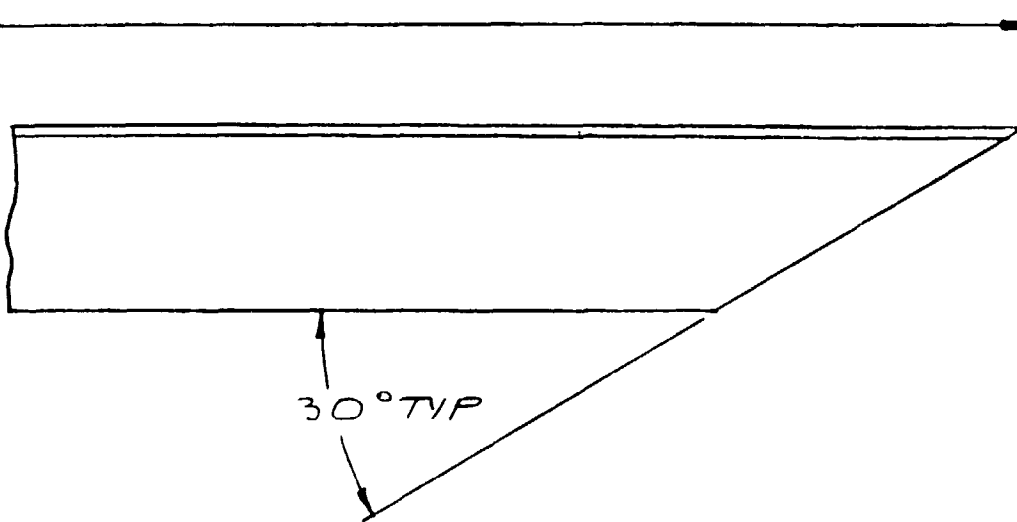
ORIGINAL PINE 18
OF POOR QUALITY




FOLDOUT FRAME

UNLESS OTHERWISE SPECIFIED	
DIMENSIONS ARE IN INCHES	
TOLERANCE ON FRACTIONS	
XXX	DE
XXX	
MATERIAL	
ALUM.	
FINAL PROTECTIVE FINISH	
~	

CENTER
OF FOLDOUT FRAME



2 FOLDOUT FRAME

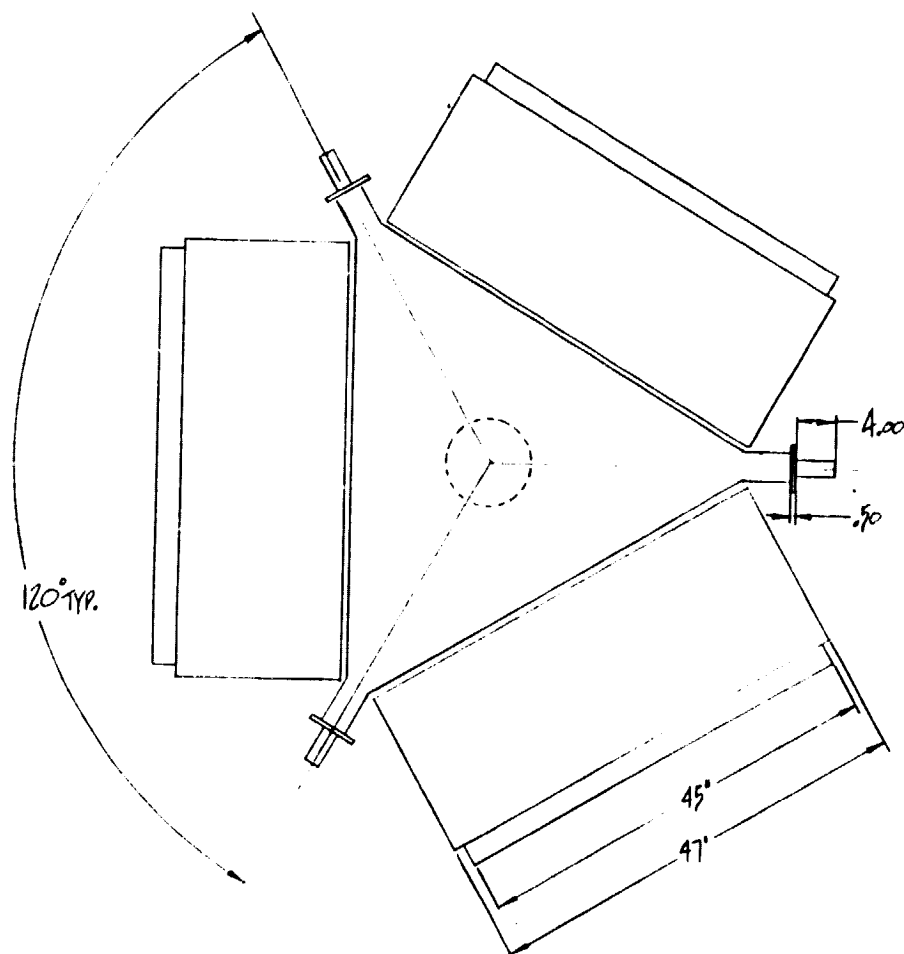
UNLESS OTHERWISE SPECIFIED		 HUNTSVILLE FACILITY 3322 S MEMORIAL PARKWAY HUNTSVILLE, AL 35801	DRAWN BY LOUGHEAD
DIMENSIONS ARE IN INCHES TOLERANCE ON DIMENSIONS DECIMALS .03 ANGLES 1/2°			DATE AUG. 20-84
MATERIAL ALUM. ALLOY			APPROVED
AL PROTECTIVE FINISH ~			CONTRACT 00478
SCALE 1/2			DRAWING NUMBER 478029
			SHEET OF

BRACE



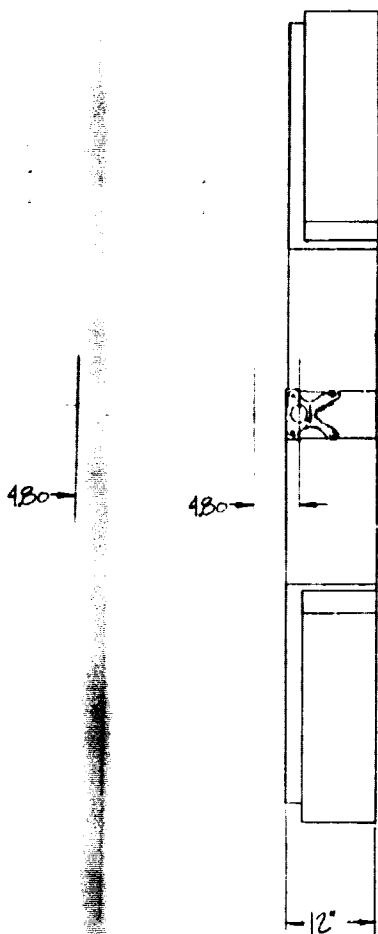
APPENDIX B: Drawings of MMS Mockup

ORIGINAL PAGE 19
OF POOR QUALITY



FOLDOUT FRAME

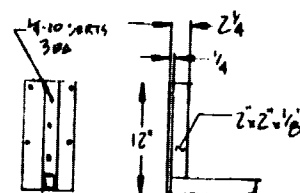
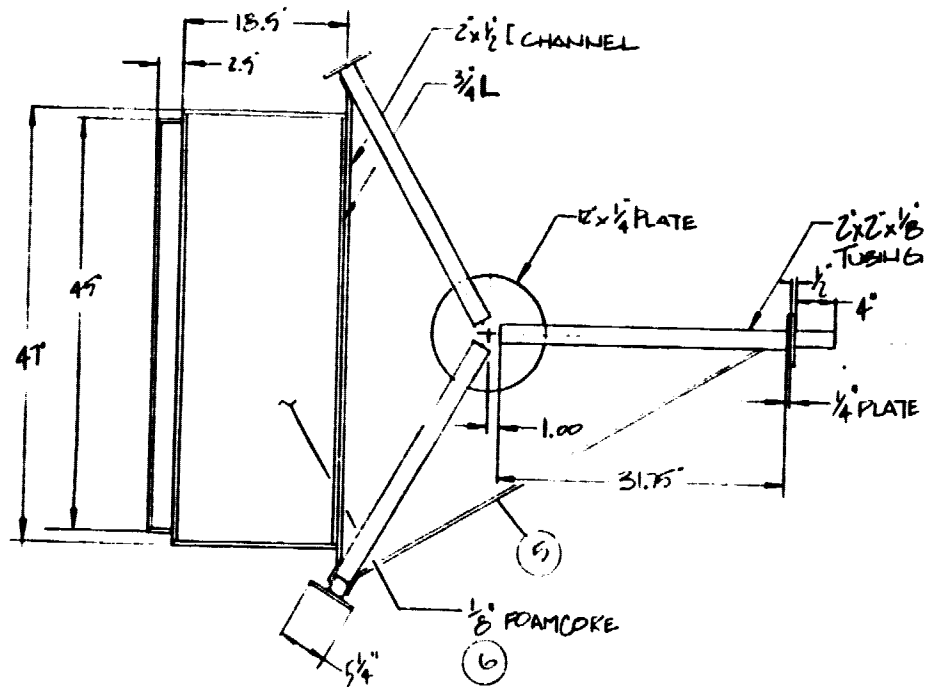
ORIGINAL PAGE IS
OF POOR QUALITY



2 FOLDOUT FEET

<input checked="" type="checkbox"/> UNLESS OTHERWISE SPECIFIED		ESSEX		HUNTSVILLE FACILITY 5000 S. MEMORIAL PARKWAY HUNTSVILLE, AL 35891	DRAWN BY RVA
DIMENSIONS ARE IN INCHES TOLERANCE ON FRACTIONS DECIMALS ANGLES 1/16 0.001 0.001		SOLAR MAX-T/O TARGET ASSEMBLY		DATE 3-22-84	
MATERIAL ALUM. FORM CORE		CONTRACT 00478		APPROVED	
FINAL PROTECTIVE FINISH ALUM. FOIL		SCALE 1"=10'		DRAWING NUMBER 478106	
				SHEET OF	

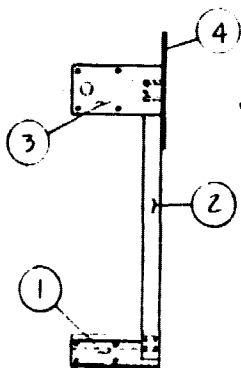
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DETAIL ①
ASSEMBLY

FOLDOUT FRAME

ORIGINAL PAGE 13
OF POOR QUALITY



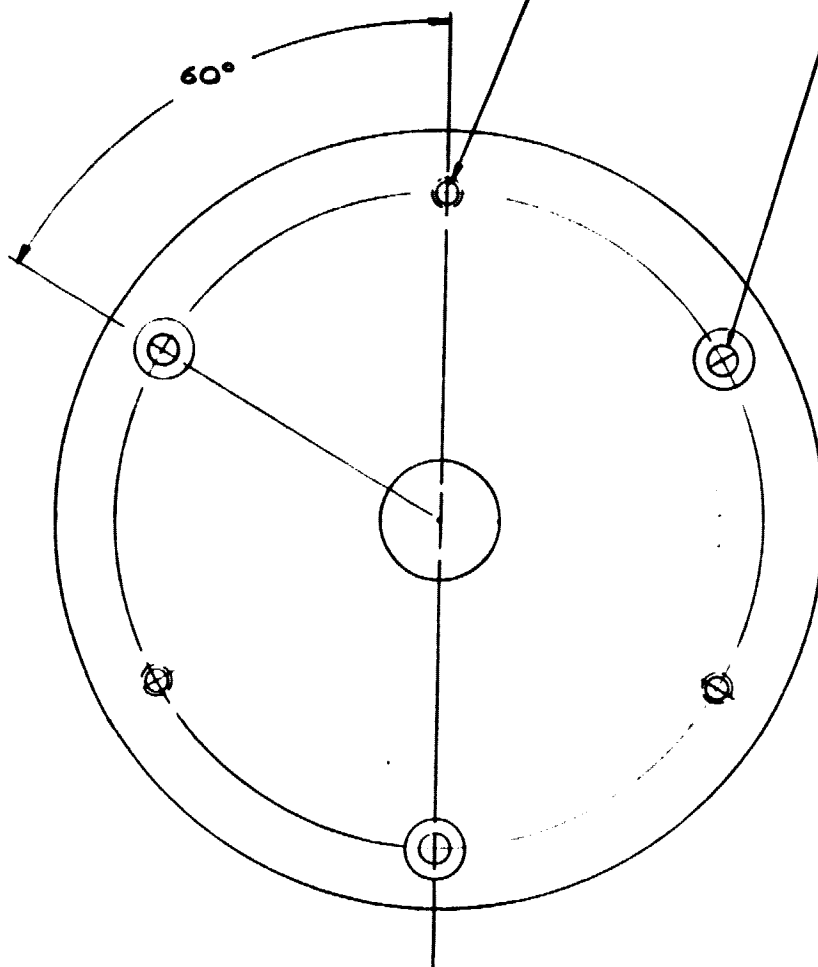
2 FOLDOUT FRAME

UNLESS OTHERWISE SPECIFIED			ESSEX HUNTSVILLE FACILITY 2025 S. MEMPHIS PARKWAY HUNTSVILLE, AL 35891		DRAWN BY EVW
DIMENSIONS ARE IN INCHES TOLERANCES ON FRACTIONS $\frac{1}{32}$			DECIMALS 0.030 0.050	ANGLE 1°	DATE 3-30-84
MATERIAL (6061) ALUM ALLOY			SOLAR MAX - T/O FRAM DETAILS		APPROVED OC 478
FINISH PROTECTIVE FORM BLACK ANODIZE					SCALE 1"=10'
					SHEET OF

ORIGINAL PAGE IS
OF POOR QUALITY

1/4-20 UNC-2A TAP THRU 3 HOLES
EQ. SPACED ON 5.500 DIA. B.C.

*H(.2660 DIA.) DRILL
EQ. SPACED ON 5.500 DIA. B.C.
C'SINK 82° X .53 DIA.

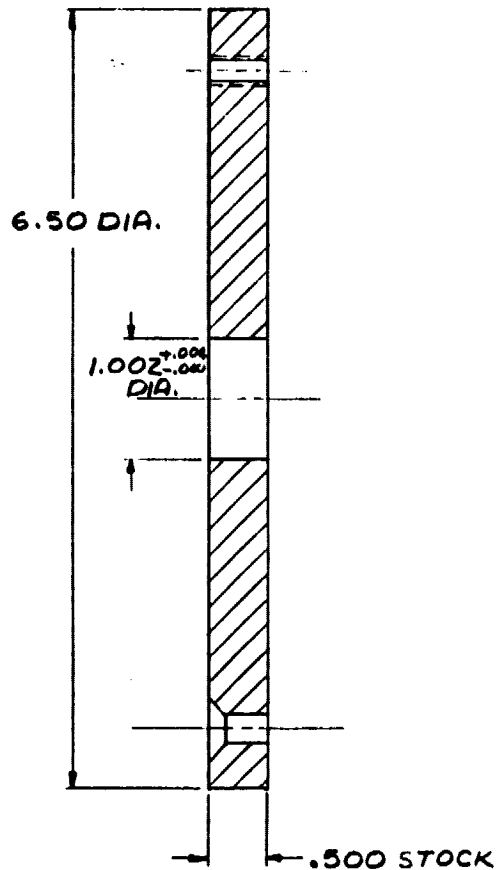


FOLDOUT FRAME

1/4-20 UNC-2A TAP THRU 3 HOLES
EQ. SPACED ON 5.500 DIA. B.C.

ORIGINAL PART OF
OF POOR QUALITY

*H(.2660 DIA.) DRILL THRU 3 HOLES
EQ. SPACED ON 5.500 DIA. B.C.
C'SINK 82° X .53 DIA. TYR

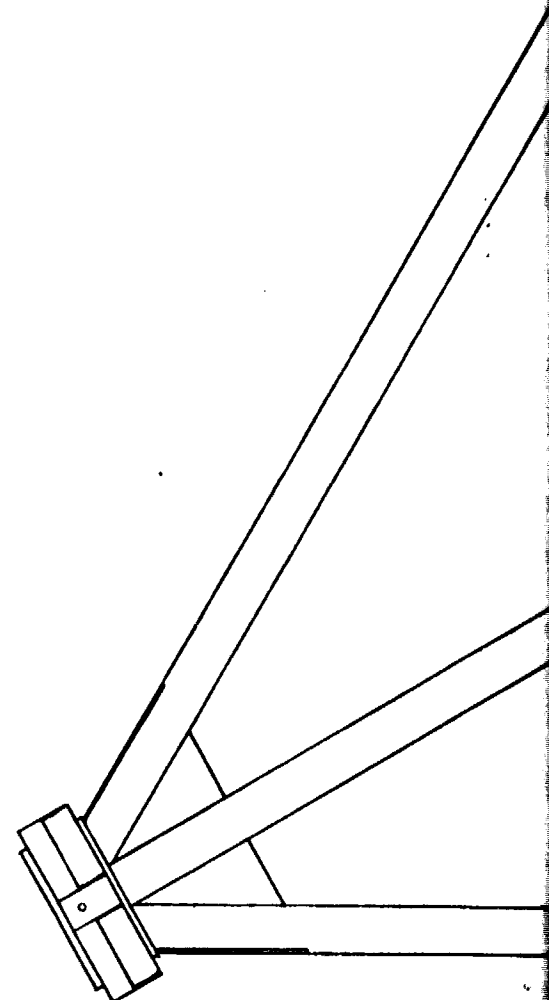
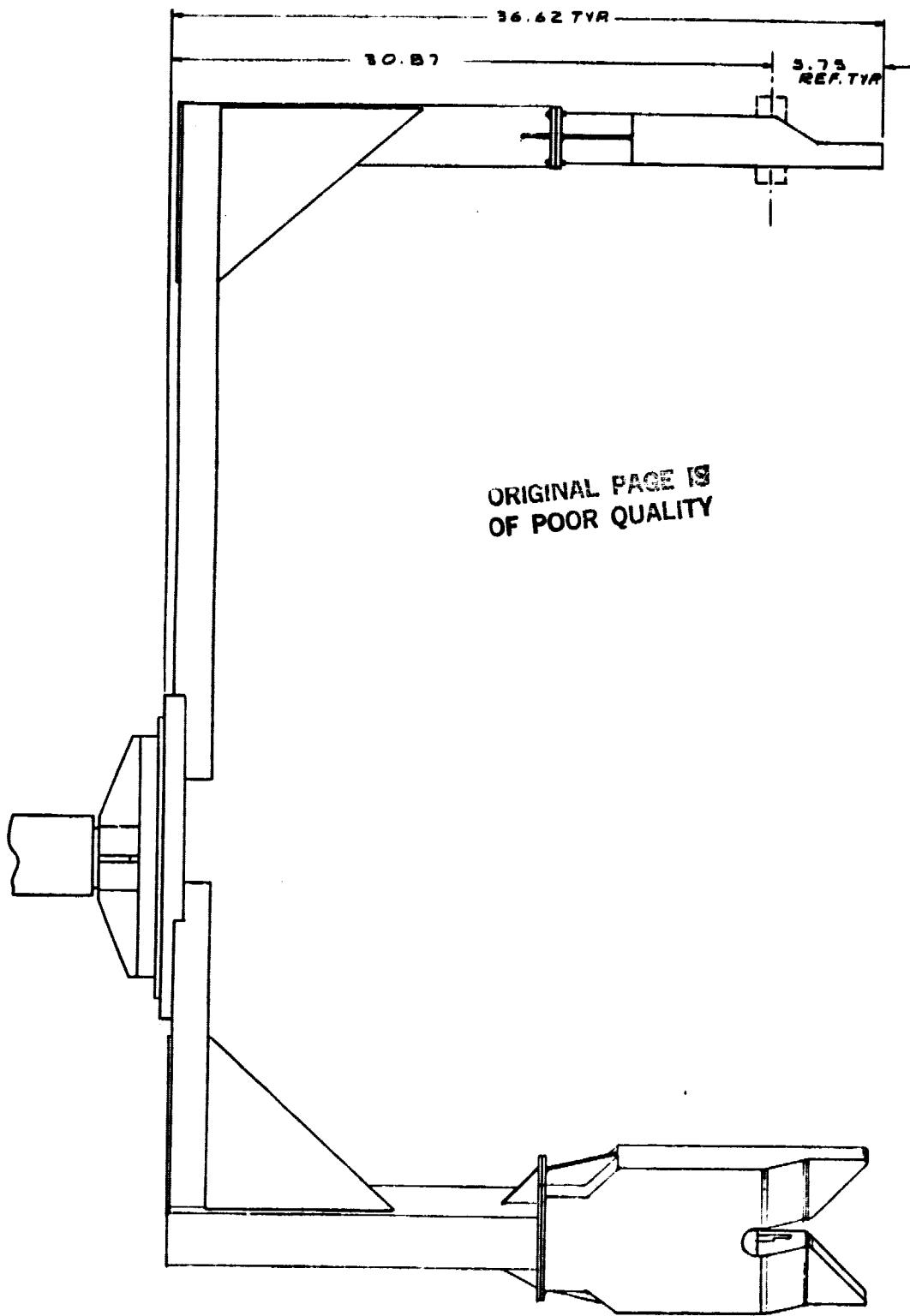


- NOTE~
UNLESS OTHERWISE SPECIFIED:
- 1- REMOVE ALL BURRS & BREAK ALL SHARP EDGES .010 R. MAX.
 - 2- TOLERANCES: .XX ± .015
.XXX ± .004
 - 3- MATERIAL: ALUMINUM ALLOY 6061-T6
 - 4- FINAL PROTECTIVE FINISH: ANODIZE, DYE BLACK

ESSEX		
SCALE: 1-1	APPROVED BY:	DRAWN BY: LOWMYER
DATE: JUL 28, '81		REVISED
MOCKUP ADAPTER PLATE		
T.M.S.		DRAWING NUMBER 810907



APPENDIX C: Drawings of Docking Device



FOLDOUT FRAME

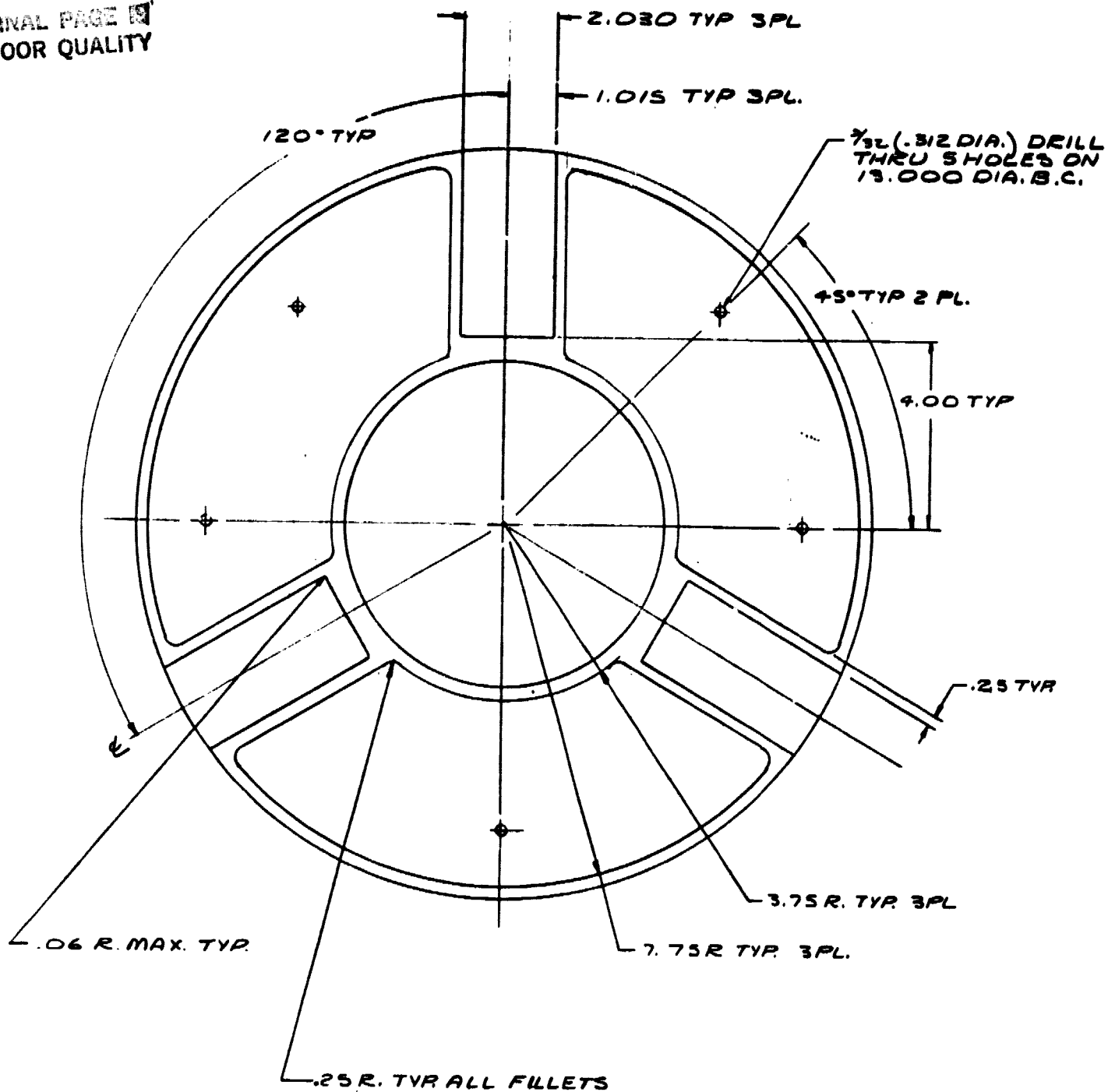
ORIGINAL PART OR
OF POOR QUALITY

35.00 TYP

2 FOLDOUT FRAME

UNLESS OTHERWISE SPECIFIED		ESSEX	MONTGOMERY FACILITY 3000 S. MEMPHIS PARKWAY MONTGOMERY, AL 36101	DRAWN BY <i>W. H. C. P. O.</i>
DIMENSIONS ARE IN INCHES FRACTIONS ON DECIMALS ANGLES 1/16 3/32 1/8 1/4 3/8 1/2 5/8 3/4 7/8 1 1 1/4 1 1/2 1 3/4 2 2 1/4 2 1/2 3 3 1/4 3 1/2 4 4 1/4 4 1/2 5 5 1/4 5 1/2 6 6 1/4 6 1/2 7 7 1/4 7 1/2 8 8 1/4 8 1/2 9 9 1/4 9 1/2 10				DATE
MATERIAL ~		CAPTURE DEVICE ASSY		APPROVED
FINAL PROTECTIVE FINISH ~				CONTRACT 00478
SCALE 1/4				DRAWING NUMBER 478300
				SHEET 01

ORIGINAL PAGE 1
OF POOR QUALITY



FOLDOUT FRAME

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES ON DIMENSIONS
FRACTIONS
DIMENSIONS
DIMENSIONS
MATERIAL
AL. ALL
FINAL PROTECTIVE COATING
NONE

ORIGINAL PAGE 14
OF POOR QUALITY

TYP 3PL

TYP 3PL.

$\frac{7}{32}$ (.312 DIA.) DRILL
THRU 5 HOLES ON
13.000 DIA. B.C.

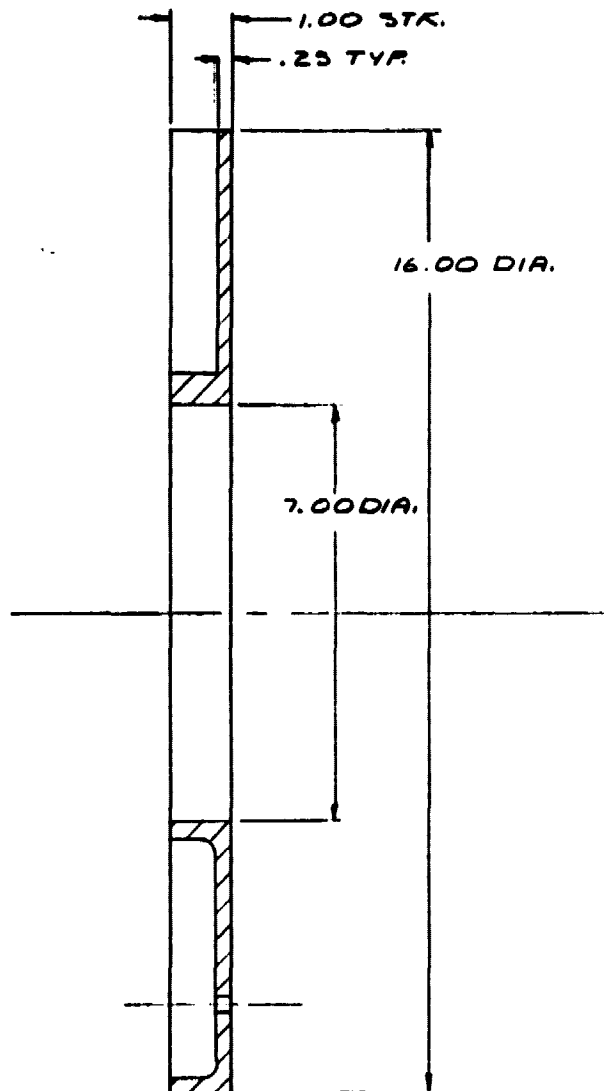
45° TYP 2 PL.

4.00 TYP

.25 TYP

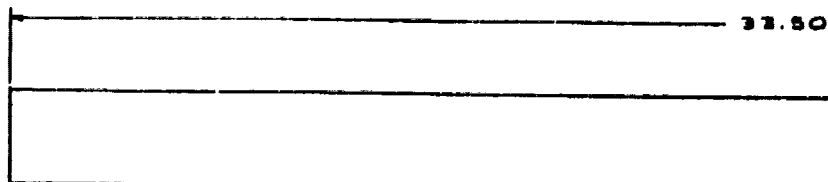
3.75 R. TYP 3PL

75 R TYP 3PL.

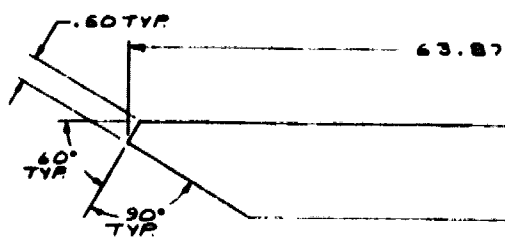


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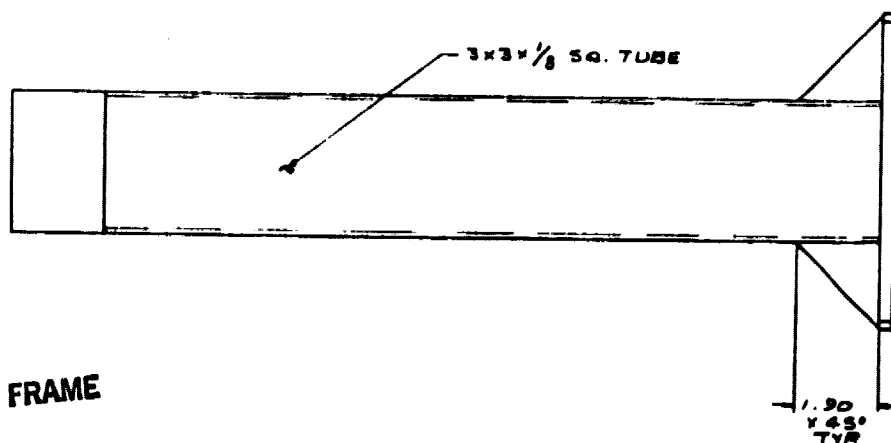
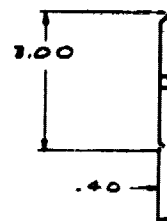
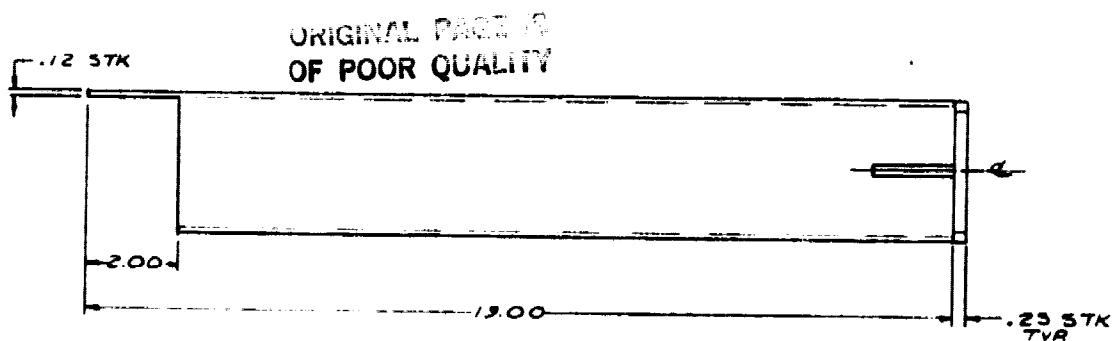
UNLESS OTHERWISE SPECIFIED		ESSEX HUNTSVILLE FACILITY 2222 S. MEMORIAL PARKWAY HUNTSVILLE, AL 35891	DRAWN BY LOUGHFAD
DIMENSIONS ARE IN INCHES TOLERANCES ON FRACTIONS DECIMALS ANGLES .005 .005 .005			PART MAN 26-84
MATERIAL AL. ALLOY		CENTER SUPPORT~ LATCH MOUNT	APPROVED
FINAL PROTECTIVE FINISH NONE			CONTRACT DD47B
SCALE 1/2			DRAWING NUMBER 478301
			SHEET OF



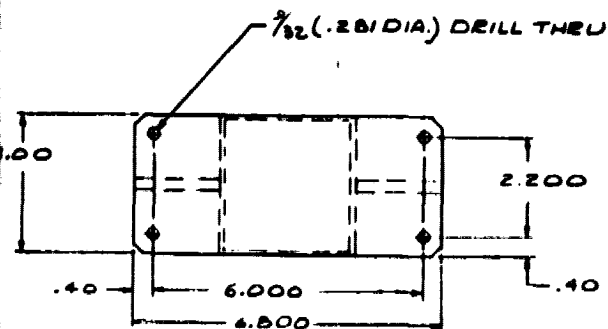
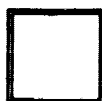
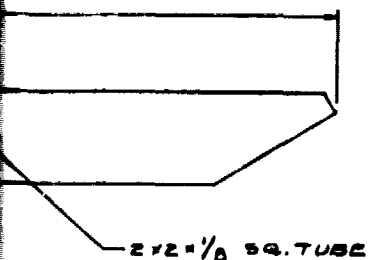
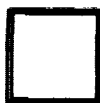
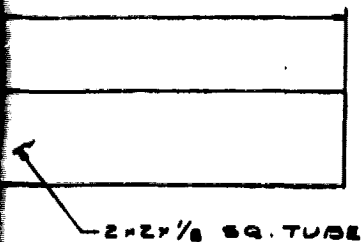
-2 RADIAL
3 REQ.



-3 DIAGONAL
3 REQ.



FOLDOUT FRAME



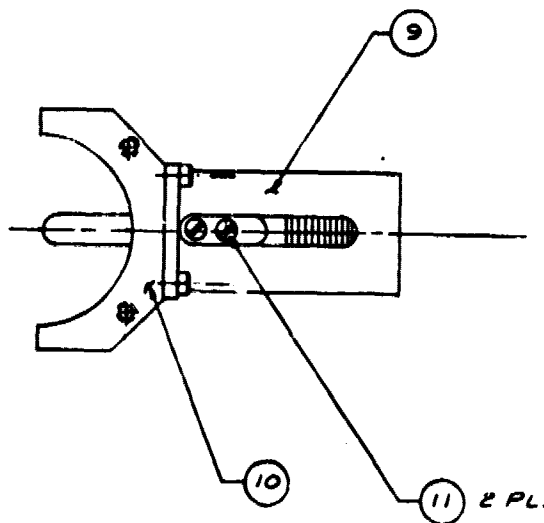
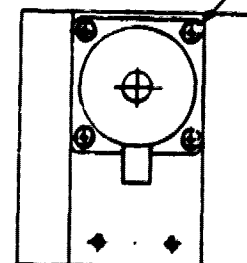
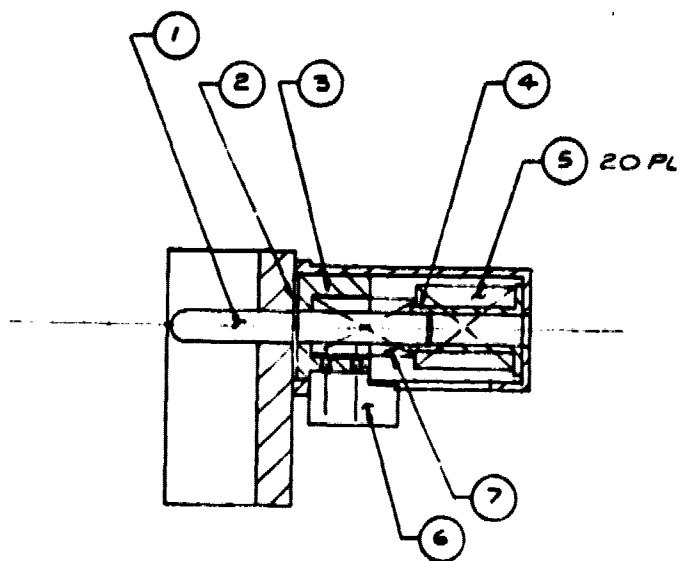
ORIGINAL 1/2
OF POOR COPY

2 FOLDOUT FRAME

- 4 LATCH MOUNT
3510.

UNLESS OTHERWISE SPECIFIED		ESSEX ELECTRONIC SYSTEMS 2000 S. UNIVERSITY PARKWAY CHICAGO, IL 60601	DESIGNED BY 1644H/AD
DIMENSIONS ARE IN INCHES TOLERANCES UNLESS OTHERWISE SPECIFIED			DATE 5-30-61
MATERIAL AL ALLOY			APPROVED BY WJL
FINISH ANODIZED			CONTRACT 00178
FINAL PROTECTIVE COATING ~		SCALE 1/2	DRAWING NUMBER 478302
			SHEET 2 of 3

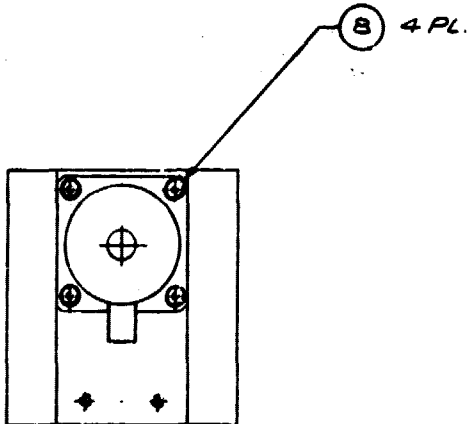
ORIGINAL PAGE 19
OF POOR QUALITY



FOLDOUT FRAME

12	
11	2
10	1
9	1
8	4
7	1
6	1
5	20
4	1
3	1
2	1
1	1
FIND Nº	QTY
UNLESS OTHERWISE SPECIFIED	
DIMENSIONS ARE IN INCHES FRACTIONS ON DENOMINATOR	
MATERIAL SPEC	
FINAL PROTECTIVE FILM	

ORIGINAL PAGE 11
OF POOR QUALITY

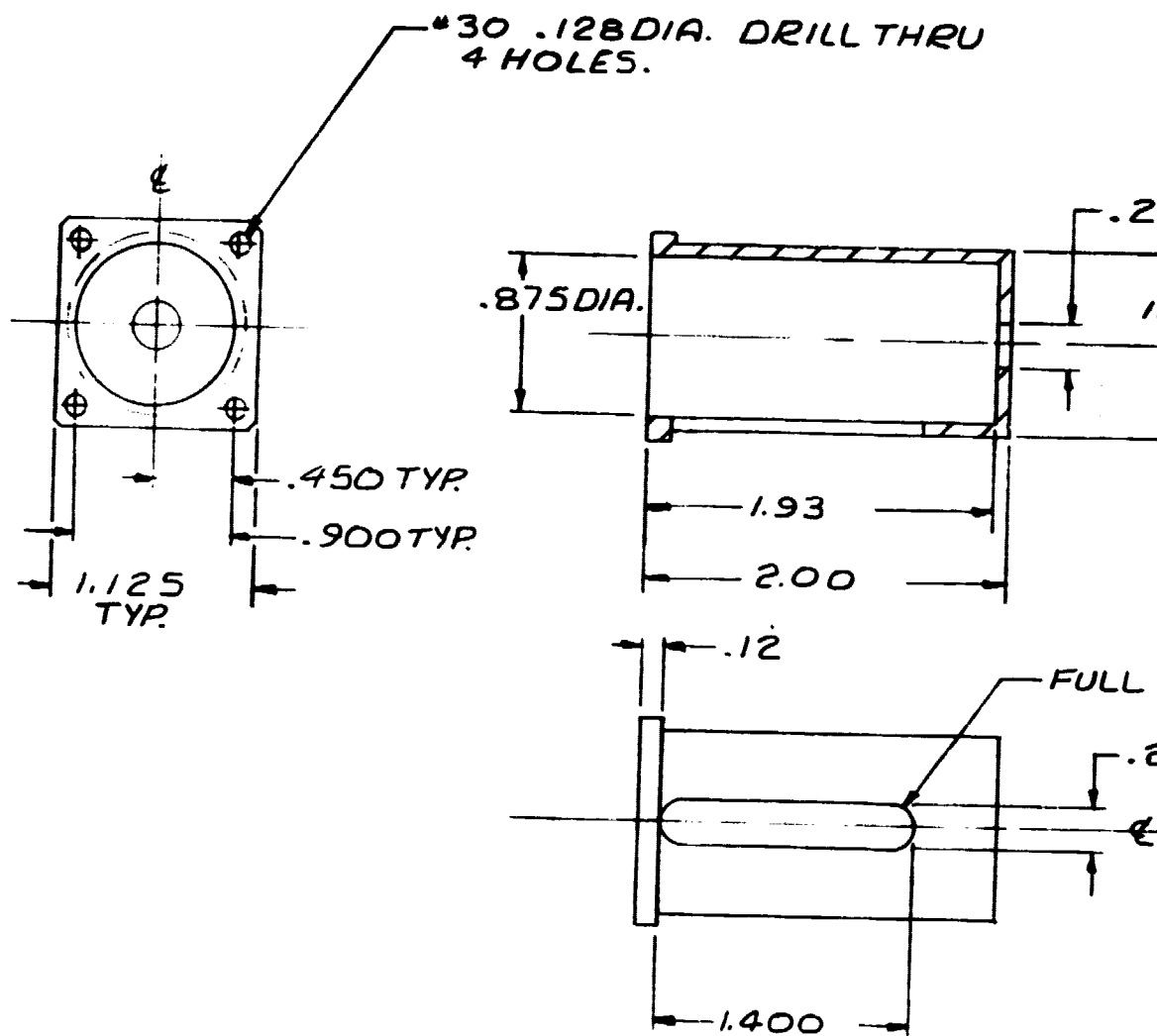


2 FOLDOUT FRAME

12				
11	2	Y6-54-A10	4-40NC FLT HD SCREW X.56 LG-CRES	BERG
10	1	478005	CENTER SUPPORT	
9	1	478002	HOUSING-SPRING PL.	
8	4	Y9-54-A6	4-40NC SOC. HD CAP SCR. X.38 LG-CRES	BERG
7	1	C0480-032-8803	SPRING-COMP-CRES	ASSOC. SPRING
6	1	478004	CAM	
5	20	B518-19.2-0.45	BELLEVILLE SPRING	BEARING ENGINEERS
4	1	478003	SPRING GUIDE	
3	1	478007	PISTON	
2	1	Q1-25	RETAINER RING	BERG
1	1	478006	PLUNGER	
FIND Nº	QTY	CAT Nº/ DWG. Nº	DESCRIPTION	NOTE

UNLESS OTHERWISE SPECIFIED			<div><div>ESSEX</div><div>MONTVILLE FACILITY 5500 S. MEMORIAL PARKWAY MONTVILLE, AL 35051</div></div>	DRAWN BY LOUGHEAD
DIMENSIONS ARE IN INCHES TOLERANCE ON FRACTIONS DECIMALS ANGLES XXX XXX				DATE 31 JAN 84
MATERIAL SEE P.L.			SPRING PLUNGER ASSY	APPROVED
FINAL PROTECTIVE FINISH ~				CONTRACT 00478
SCA 8 1-1				DRAWING NUMBER 478001
				SHEET OF

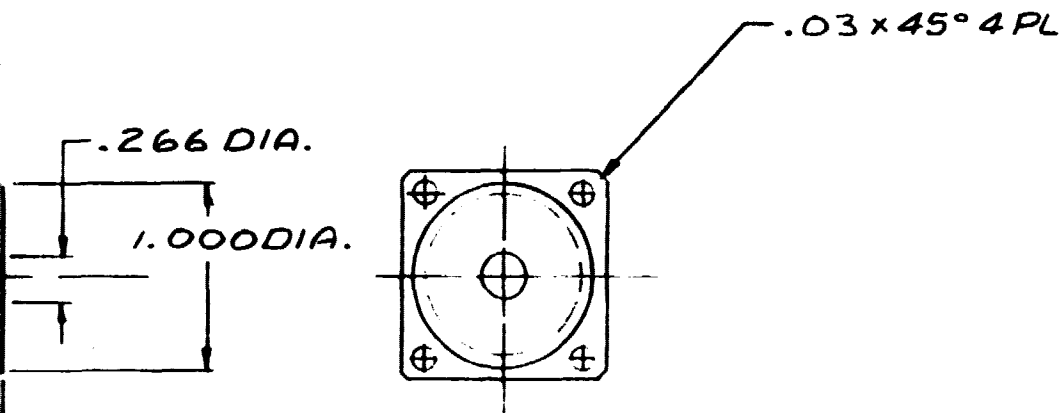
ORIGINAL PAGE 13
OF POOR QUALITY



FOLDOUT FRAME

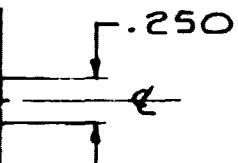
UNLESS OTHERWISE SPECIFIED	
DIMENSIONS ARE IN INCHES	
TOLERANCE ON FRACTIONS	DECIMALS
~	XX2.0
	XXX2.0
MATERIAL	
ALUM. ALLOY	
FINAL PROTECTIVE FINISH	
HARD ANODIZING	
.5 TO 1.5 MIL THICK	

ORIGINAL PAGE 12
OF POOR QUALITY



NOTE~
1- REMOVE ALL BURRS & BREAK
ALL SHARP EDGES .01-.02 R.
2- ALL FILLETS .03 R.

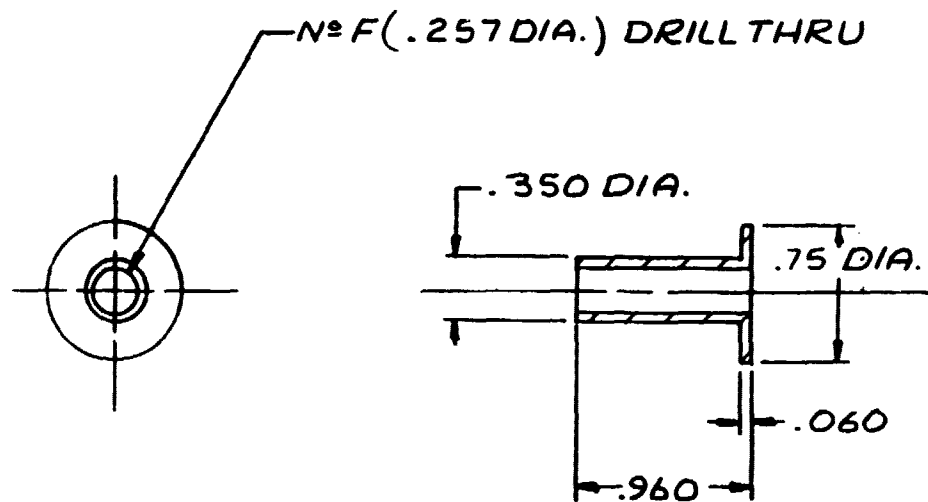
FULL R. TYR



2 FOLDOUT FRAME

UNLESS OTHERWISE SPECIFIED			HUNTSVILLE FACILITY 3322 S. MEMORIAL PARKWAY HUNTSVILLE, AL. 35801	DRAWN BY LOUGHEAD
ALL DIMENSIONS ARE IN INCHES DECIMALS XX .015 XXX .005				DATE JAN. 23 '84
MATERIAL M. ALLOY 6061-T6		HOUSING~ SPRING PLUNGER	APPROVED <i>[Signature]</i>	
PROTECTIVE FINISH D ANODIZE 1.5 MIL THICK			CONTRACT 00478	
SCALE 1-1			DRAWING NUMBER 478002	
				SHEET OF

ORIGINAL PAGE 19
OF POOR QUALITY



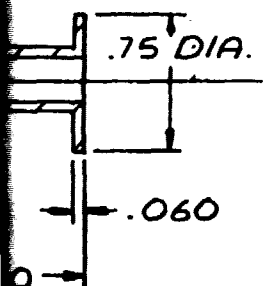
FOLDOUT FRAME

UNLESS OTHERWISE SPECIFIED	
DIMENSIONS ARE IN INCHES	
TOLERANCE ON	
FRACTIONS	DECIMALS
~	.XX2
	.XXX2
MATERIAL	
ALUM. ALLOY	
FINAL PROTECTIVE FINISH	
HARD ANODIZE	
.5 TO 1.5 MIL	

20397

ORIGINAL FILED
OF POOR QUALITY

DRILL THRU



NOTE ~
1- REMOVE ALL BURRS & BREAK
ALL SHARP EDGES .01-.02 R.

2 FOLDOUT FRAME

UNLESS OTHERWISE SPECIFIED

DIMENSIONS ARE IN INCHES
TOLERANCE ON

FRACTIONS	DECIMALS	ANGLES
~	.XX2 .015 .XXX2 .005	~

MATERIAL
ALUM. ALLOY 6061-T6

FINAL PROTECTIVE FINISH
HARD ANODIZE
.5 TO 1.5 MIL. THICK

SCALE
1-1

ESSEX

HUNTSVILLE FACILITY
3322 S. MEMORIAL PARKWAY
HUNTSVILLE, AL. 35891

SPRING GUIDE

DRAWN BY
LOUGHEAD

DATE
JAN. 23 - '84

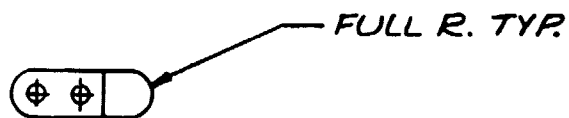
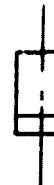
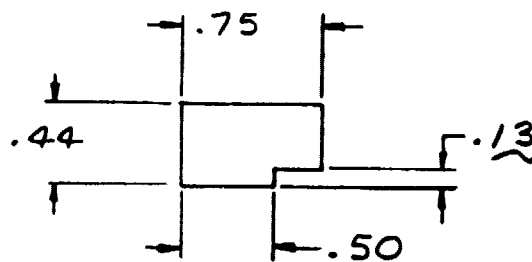
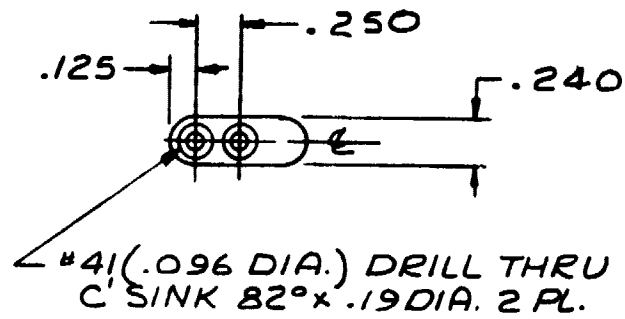
APPROVED
[Signature]

CONTRACT
00478

DRAWING NUMBER
478003

SHEET OF

ORIGINAL PAGE IS
OF POOR QUALITY



FOLDOUT FRAME

UNLESS OTHERWISE SPECIFIED	
DIMENSIONS ARE IN INCHES	
TOLERANCE ON DIMENSIONS	
FRACTIONS	DECIMALS
~	.XX2
	.XXX
MATERIAL	
ALUM. ALLOY	
FINAL PROTECTIVE FINISH	
HARD ANODIZE	
.5 TO 1.5 MIL	

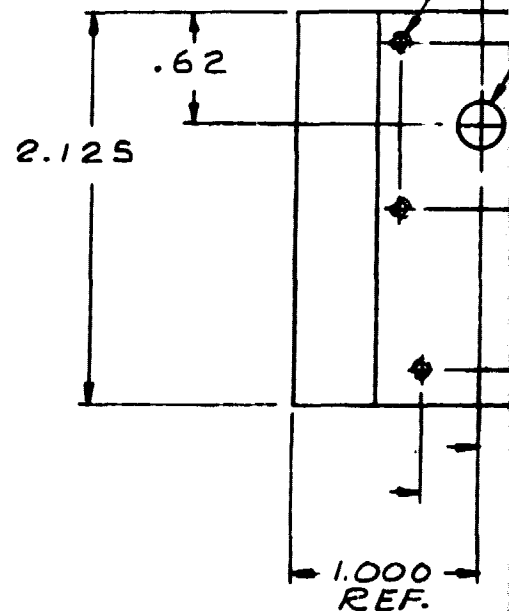
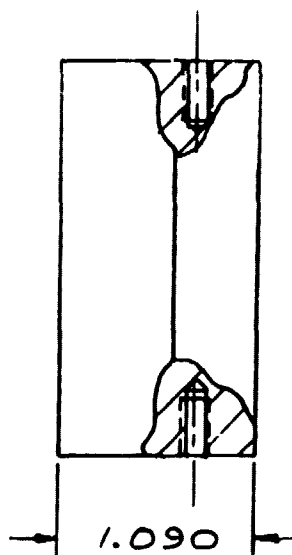
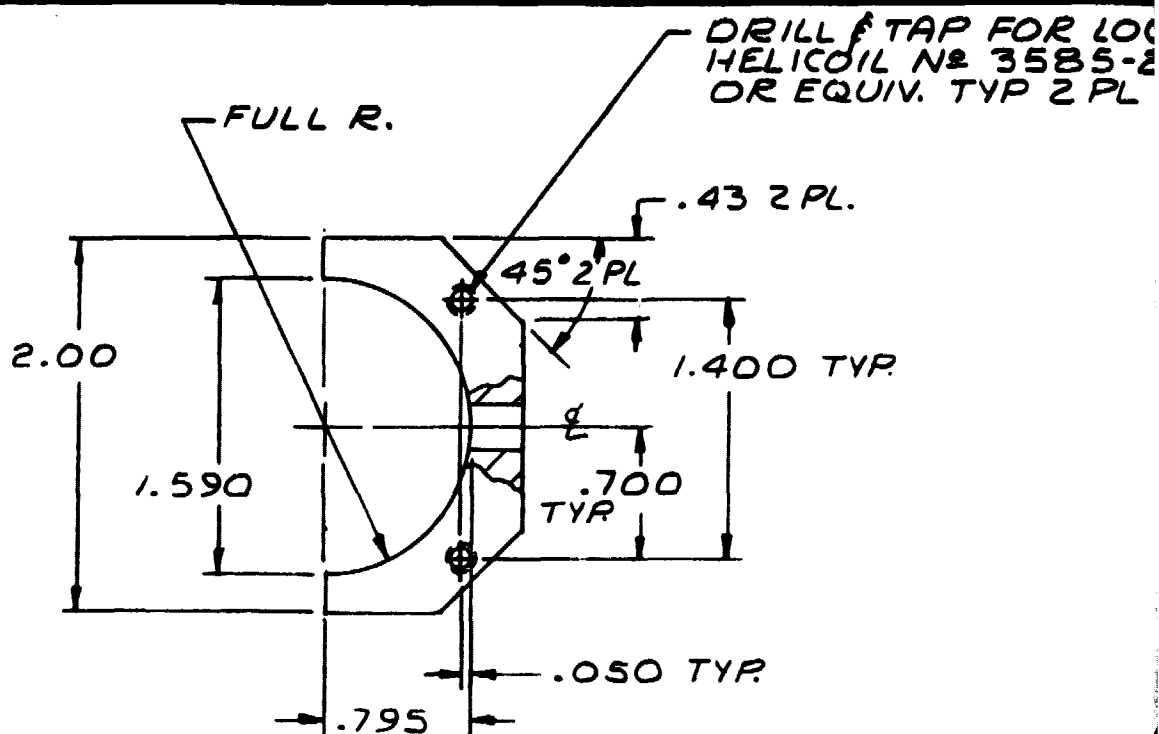
ORIGINAL PAGE
OF FOUR COPIES

NOTE~
1- REMOVE ALL BURRS & BREAK
ALL SHARP EDGES. 01-.02R

2 FOLDOUT FRAME

UNLESS OTHERWISE SPECIFIED		<div style="border: 1px solid black; padding: 5px; display: inline-block;"> ESSEX </div>		HUNTSVILLE FACILITY 3322 S. MEMORIAL PARKWAY HUNTSVILLE, AL. 35801		DRAWN BY LOUG HEATON	
DIMENSIONS ARE IN INCHES TOLERANCE ON FRACTIONS DECIMALS ANGLES ~ .XX± .015 ~ .XXX± .005		CAM		DATE 23 JAN. 84		APPROVED <i>[Signature]</i>	
MATERIAL ALUM. ALLOY 6061-T6				CONTRACT 00478			
SURFACE FINISH HARD ANODIZE 5 TO 1.5 MIL THK				DRAWING NUMBER 478004			
SCALE 1-1				SHEET OF			

ORIGINAL PAGE IS
OF POOR QUALITY



FOLDOUT FRAME

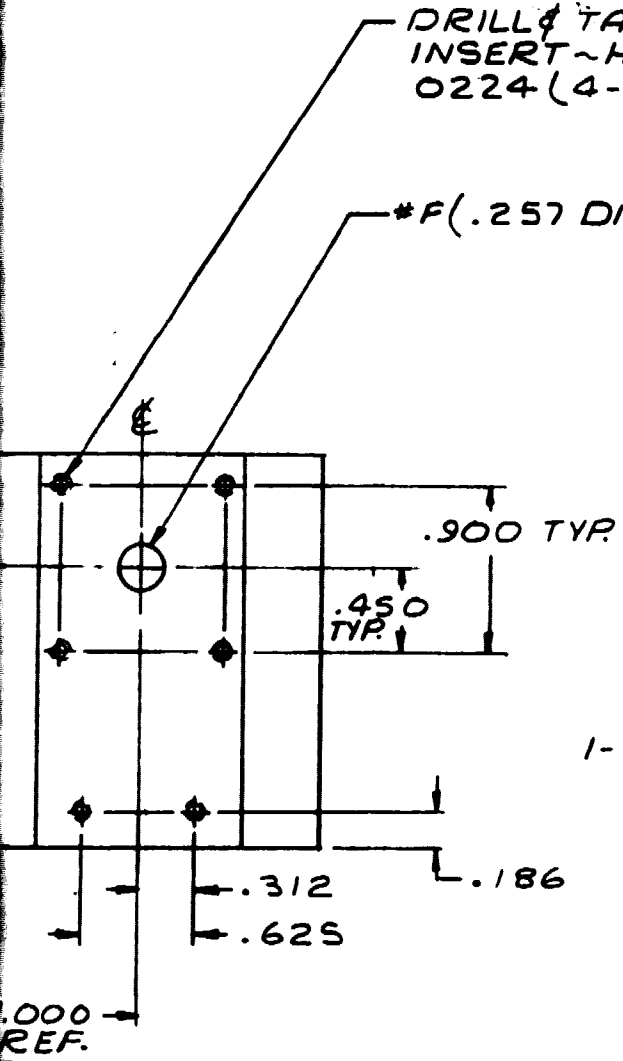
UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCE ON DIMENSIONS
FRACTIONS
DECIMALS
MATERIAL
ALUM. ALLOY
FINAL PROTECTIVE FINISH
HARD ANODIZE
.5 TO 1.5 MILS

FOR LOCKING THREADED INSERT
3585-2CN-0328 (8-32NCx2D)
P 2 PL BOTH SIDES.

ORIGINAL SIZE
OF POOR QUALITY

DRILL & TAP FOR LOCKING THREADED
INSERT ~ HELICOIL N# 3585-04CN-
0224 (4-40NCx2D) OR EQUIV. TYP 6 PL.

*F (.257 DIA.) DRILL THRU

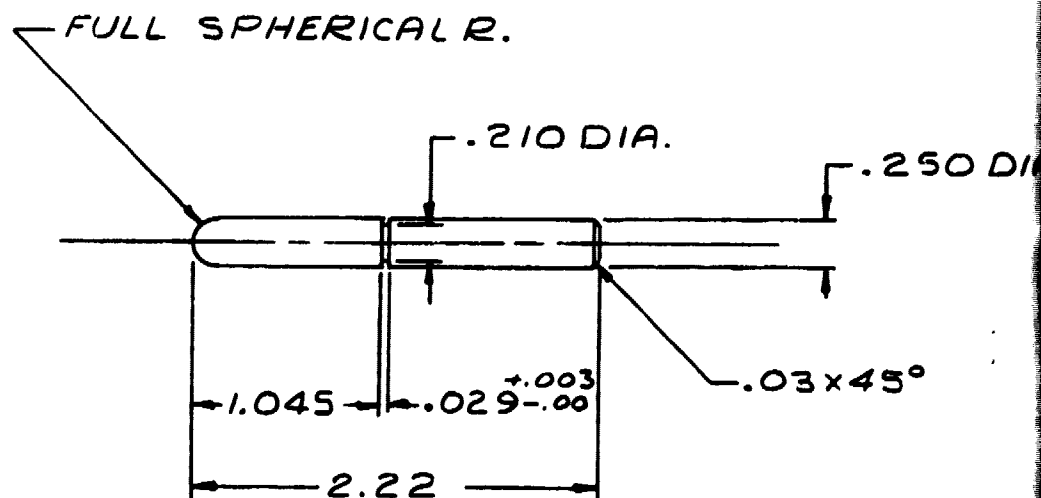


2 FOLDOUT FRAME

NOTE~
1- REMOVE ALL BURRS & BREAK
ALL SHARP EDGES .01-.02 R.

UNLESS OTHERWISE SPECIFIED		ESSEX	MUNTSVILLE FACILITY 3322 S. MEMORIAL PARKWAY MUNTSVILLE, AL. 36001	DRAWN BY LOUGHEAD
DIMENSIONS ARE IN INCHES TOLERANCES ON DIMENSIONS				DATE JAN. 24, '84
DECIMALS XX ± .013 XXX ± .005		CENTER SUPPORT		APPROVED
MATERIAL ALUM. ALLOY 6061-T6				CONTRACT 00478
PROTECTIVE FINISH ANODIZE TO 1.5 MIL THK				DRAWING NUMBER 478005
SCALE 1-1				SHEET OF

ORIGINAL PAGE IS
OF POOR QUALITY



FOLDOUT FRAME

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCE ON DIMENSIONS
FRACTIONS
XX
XX
MATERIAL
303 CR
FINAL PROTECTIVE FILM
~

ORIGINAL DRAWING
OF POOR QUALITY

250 DIA. STK.

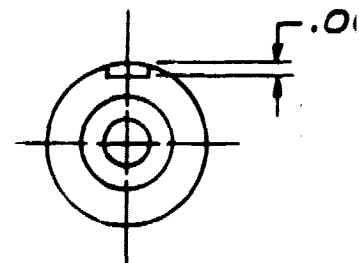
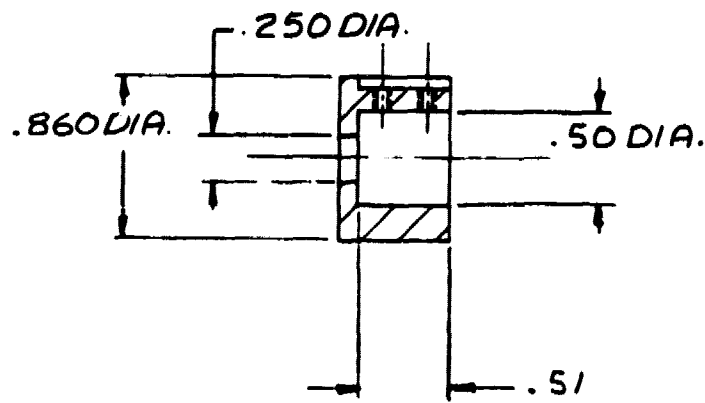
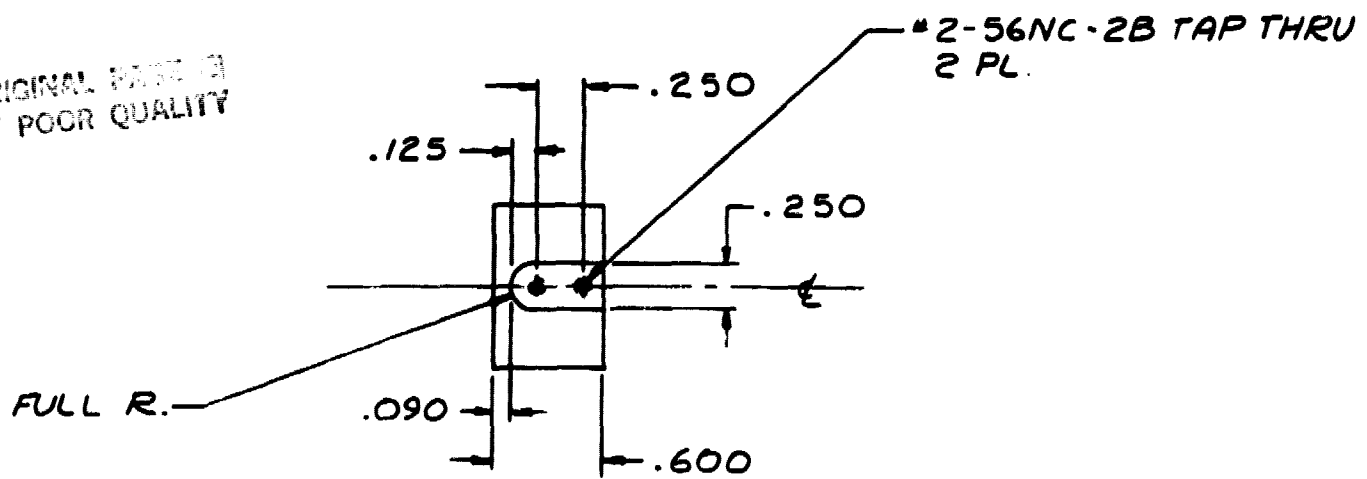


NOTE ~
1- REMOVE ALL BURRS & BREAK ALL
SHARP EDGES .01 - .02 R.

2 FOLDOUT FRAME

UNLESS OTHERWISE SPECIFIED		ESSEX	HUNTSVILLE FACILITY 3322 S. MEMORIAL PARKWAY HUNTSVILLE, AL. 35891	DRAWN BY LOUGHEAD
DIMENSIONS ARE IN INCHES DIMENSIONS ON TIONS				DATE JAN 24 - '84
DECIMALS .XX2 .015 .XXX2 .003		ANGLES 1°	APPROVED <i>John</i>	CONTRACT 00478
MATERIAL 03 CRES		PLUNGER	DRAWING NUMBER 478006	SHEET OF
PROTECTIVE FINISH ~	SCALE 1-1			

ORIGINAL PAGE 1A
OF POOR QUALITY



FOLDOUT FRAME

UNLESS OTHERWISE SPECIFIED	
DIMENSIONS ARE IN INCHES	
TOLERANCE ON	
FRACTIONS	DECIMALS
~	.XX2
	.XXX
MATERIAL	
ALUM. ALL	
FINAL PROTECTIVE FINISH	
HARD ANOD	
.5 TO 1.5 MIL	

P THRU

ORIGINAL
OF POOR QUALITY

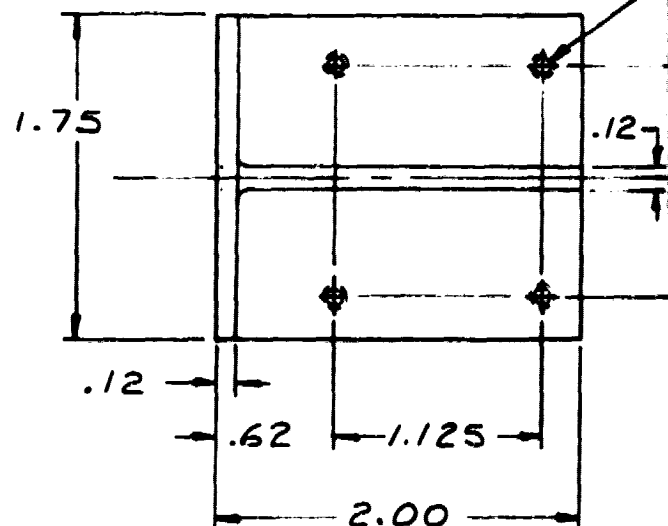
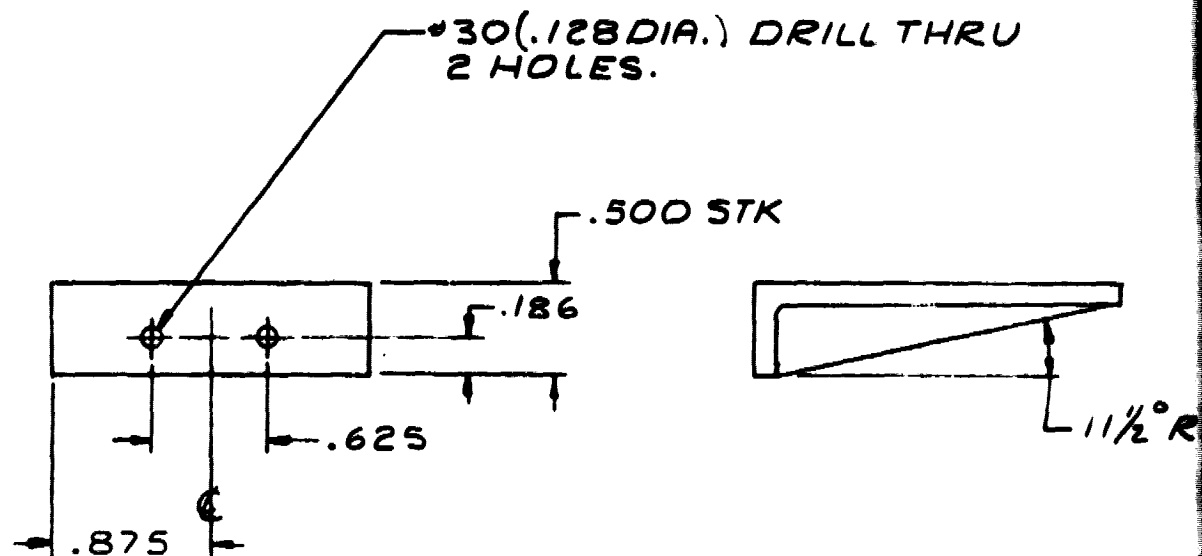
.06

NOTE ~
1- REMOVE ALL BURRS & BREAK
ALL SHARP EDGES .01-.02R.

2 FOLDOUT FRAME

UNLESS OTHERWISE SPECIFIED		ESSEX	HUNTSVILLE FACILITY 3322 S. MEMORIAL PARKWAY HUNTSVILLE, AL. 35891	DRAWN BY LOUGHEAD
DIMENSIONS ARE IN INCHES DIMENSIONS ON DIMENSIONS				DATE JAN. 23 '84
DECIMALS XX2 .015 XXX2 .005		PISTON		APPROVED <i>John</i>
MATERIAL MIL. ALLOY 6061-T6				CONTRACT 00478
PROTECTIVE FINISH RD ANODIZE 01.5 MIL THK	SCALE 1-1			DRAWING NUMBER 478007
				SHEET OF

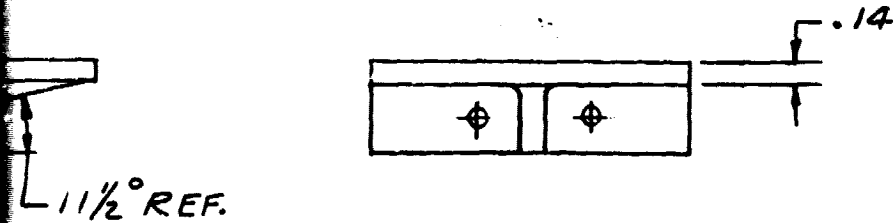
ORIGINAL PAGE 15
OF POOR QUALITY



FOLDOUT FRAME

UNLESS OTHERWISE SPECIFIED	
DIMENSIONS ARE IN INCHES	
TOLERANCE ON	
FRACTIONS	DECIMALS
	±.005
	±.002
MATERIAL	
ALUM. ALL	
FINAL PROTECTIVE FINISH	
ALODYNE	

ORIGINAL DRAWING
OF POOR QUALITY



DRILL & TAP FOR LOCKING THREADED INSERT~
HELICOIL N^o 3585-04CN-0168 (4-40NCx1.5D)
OR EQUIV.

NOTE~
1- REMOVE ALL BURRS & BREAK
ALL SHARP EDGES .01-.02R.
2- ALL FILLETS .06R.

➤ FOLDOUT FRAME

UNLESS OTHERWISE SPECIFIED

ALL DIMENSIONS ARE IN INCHES
UNLESS OTHERWISE SPECIFIED

DECIMALS ANGLES
XX 2 .015
XXX 2 .005

MATERIAL ALLOY 6061-T6

SELECTIVE FINISH
DYNE

SCALE
1-1

ESSEX

HUNTSVILLE FACILITY
3322 S. MEMORIAL PARKWAY
HUNTSVILLE, AL. 35801

BRACKET

DRAWN BY
LOUGHEAD

DATE
30 JAN. 84

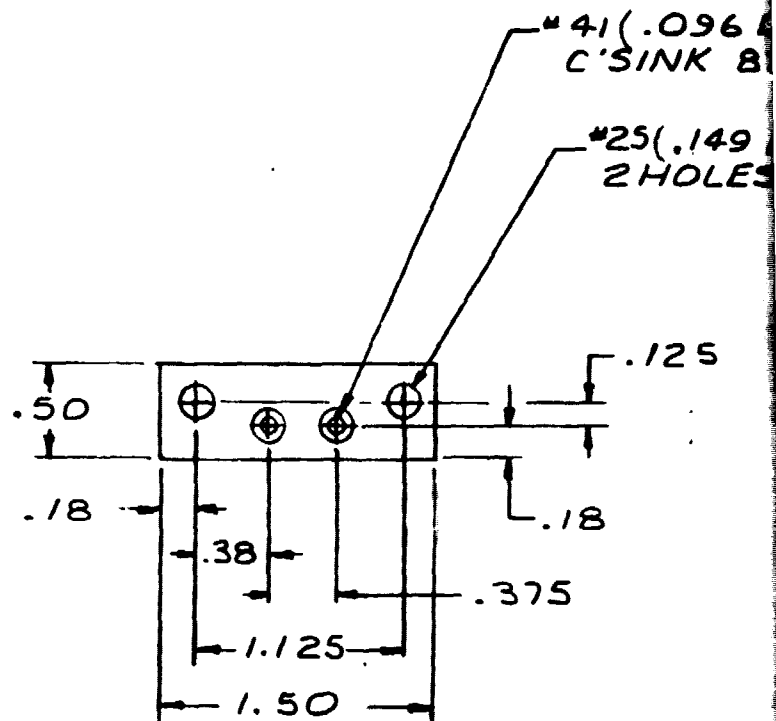
APPROVED

CONTRACT
00478

DRAWING NUMBER
478008

SHEET OF

ORIGINAL PAGE IS
OF POOR QUALITY



FOLDOUT FRAME

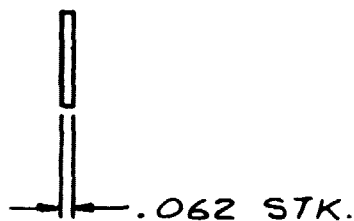
UNLESS OTHERWISE SPECIFIED	
DIMENSIONS ARE IN INCHES	
TOLERANCE ON	
FRACTIONS	DECIMALS
~	XX2.0
	XXX2.0
MATERIAL	
ALUM. ALLOY	
FINAL PROTECTIVE FINISH	
ALODYNE	

ORIGINAL DRAWING
OF POOR QUALITY

#1 (.096 DIA.) DRILL THRU
SINK 82°x.18 DIA. - 2 PL.

#25 (.149 DIA.) DRILL THRU
2 HOLES.

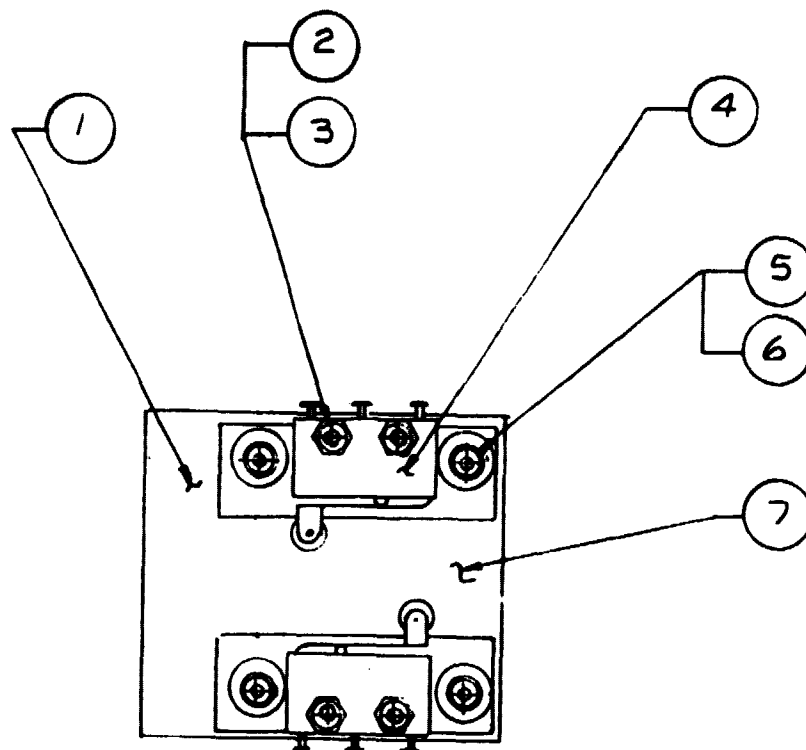
.125



NOTE~
1- REMOVE ALL BURRS & BREAK
ALL SHARP EDGES .01-.02 R.

2 FOLDOUT FRAME

UNLESS OTHERWISE SPECIFIED		ESSEX HUNTSVILLE FACILITY 3322 S. MEMORIAL PARKWAY HUNTSVILLE, AL. 35801	DRAWN BY LDU6HEAD
DIMENSIONS ARE IN INCHES DECIMALS ANGLES .XX2 .015 ~ .XXX2 .005			DATE JAN 30-'84
M. ALLOY 6061-T6		SWITCH MOUNTING PLATE	APPROVED
PROTECTIVE FINISH ODDYNE	SCALE 1-1		CONTRACT 00478
			DRAWING NUMBER 478009
			SHEET OF



ORIGINAL PAGE 19
OF POOR QUALITY


FOLDOUT FRAME

7	2	
6	4	
5	4	
4	2	
3	4	
2	4	
1	1	
FIND No	QTY	
UNLESS OTHERWISE SPECIFIED		
DIMENSIONS ARE IN INCHES TOLERANCE ON FRACTIONS DEC XXS XXXS		
MATERIAL SEE REF		
FINAL PROTECTIVE FINISH ~		

ORIGINAL PAGE IS
OF POOR QUALITY.

2 FOLDOUT FRAME

7	2	478009	SWITCH MOUNTING PLATE	
6	4	Y9-S4-A4	SOL. HD CAP SCREW 4-40NC x .25 LG.	BERG
5	4	24-4	FLAT WASHER-#4	BERG
4	2	111SM2-T	SWITCH	MICRO SWITCH
3	4	Y5-2	NUT 2-56NC	BERG
2	4	Y6-S2-A6	SCREW F.H. 2-56 x .38 LG.	BERG
1	1	478008	BRACKET	
ND 1/2	QTY	CAT. N ^o / DWG N ^o	DESCRIPTION	NOTE

UNLESS OTHERWISE SPECIFIED		 <p>HUNTSVILLE FACILITY 3322 S. MEMORIAL PARKWAY HUNTSVILLE, AL 35801</p>	DRAWN BY LOUGHEAD
DIMENSIONS ARE IN INCHES TOLERANCE ON FRACTIONS			DATE JAN. 30-'84
DECIMALS ANGLES XX2 XXX2			APPROVED
SERIAL SEE P.L.			CONTRACT 00478
ALL PROTECTIVE FINISH ~			DRAWING NUMBER 478010
SCALE 1-1		SHEET OF	

SWITCH ASSY.

• 500 DIA. THRU
• 499

[-.750 DIA.
STK.

— .250 STK.

.625 STK

06 R.TYP.
3 PL.

-1.60 R.

- 1.10 R.

550
R. ✓

1.63

.75 R=

.04

4.50 R.

- 1.56

102°

80°

220

L#30(.128 DIA.) DRILL
THRU 2 HOLES

FOLDOUT FRAME

UNLESS OTHER

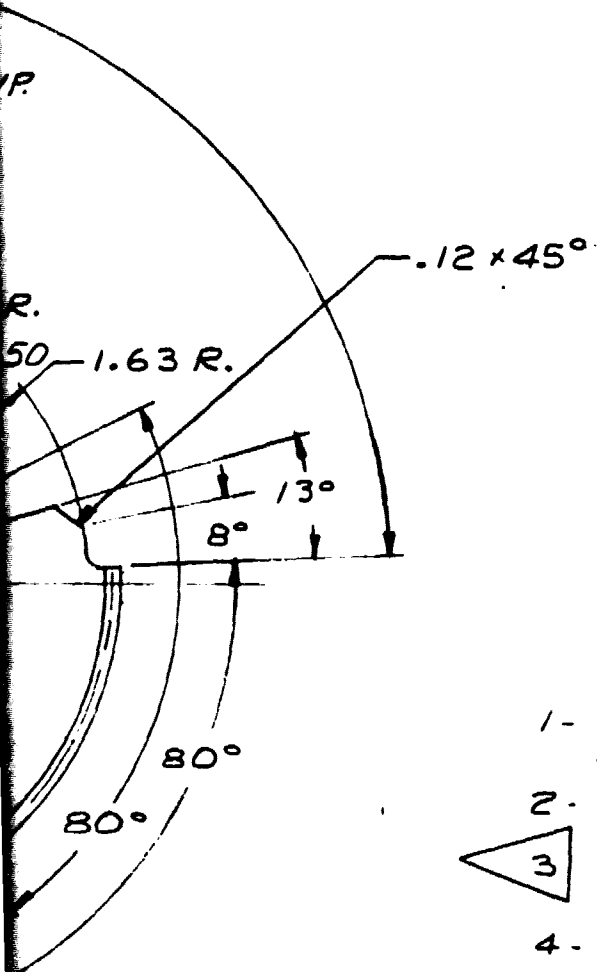
DIMENSIONS ARE IN INCHES
TOLERANCE ON
FRACTIONS

MATERIAL

3

FINAL PROTECTIVE FINISH

ORIGINAL PAGE IS
OF POOR QUALITY



NOTE~

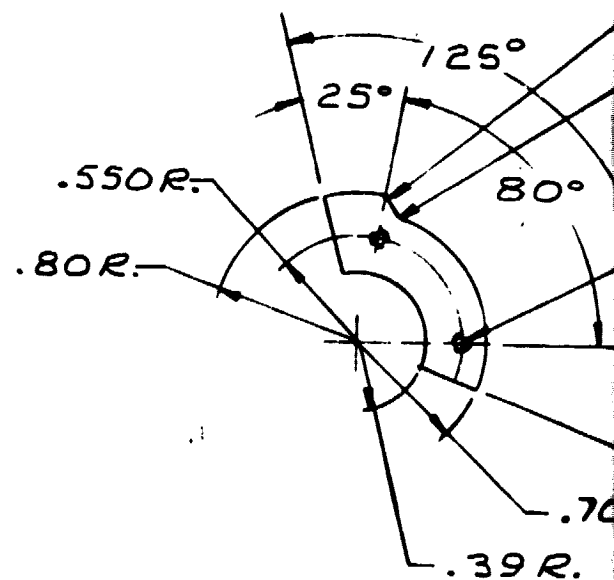
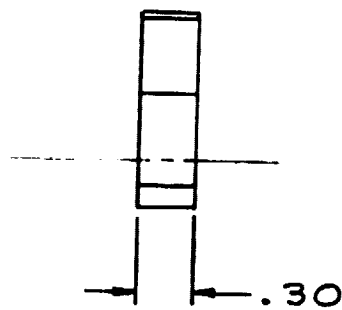
- 1- REMOVE ALL BURRS & BREAK ALL SHARP EDGES .01-.02 R.
- 2- ALL FILLETS .09 R.
- 3 MAKE FROM BERG GEAR NO P20S33-70
- 4- PN 478011-1 SHOWN
478011-2 OPPOSITE

A) DRILL
HOLES

2 FOLDOUT FRAME

UNLESS OTHERWISE SPECIFIED			HUNTSVILLE FACILITY 3322 S. MEMORIAL PARKWAY HUNTSVILLE, AL. 35801		DRAWN BY LOUGHEAD	
DIMENSIONS ARE IN INCHES TOLERANCES ON DIMENSIONS			CAM - LATCH		DATE FEB 3 '84	
DECIMALS XX ± .015 XXX ± .005		APPROVED				
ANGLES 1/2°		CONTRACT 00478				
MATERIAL 303 CRES		DRAWING NUMBER 478011				
PROTECTIVE FINISH		SCALE 1-1		SHEET OF		

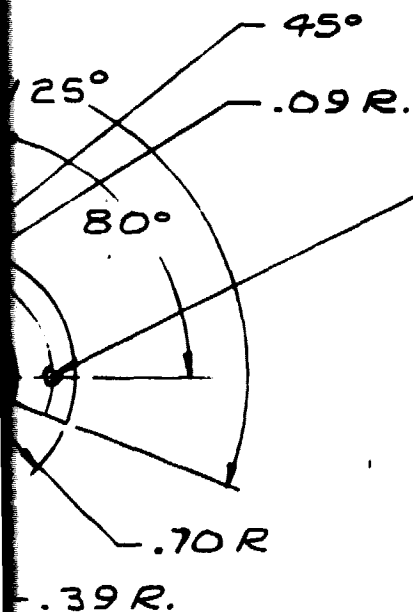
ORIGINAL PAGE IS
OF POOR QUALITY



FOLDOUT FRAME

UNLESS OTHERWISE SPECIFIED	
DIMENSIONS ARE IN INCHES	
TOLERANCE ON	
FRACTIONS	DECIMALS
XXS - .005	XXXS - .001
MATERIAL	
ALUM. ALL	
FINAL PROTECTIVE FINISH	
CLEAR ANOD	


ORIGINAL DESIGN
OF POOR QUALITY

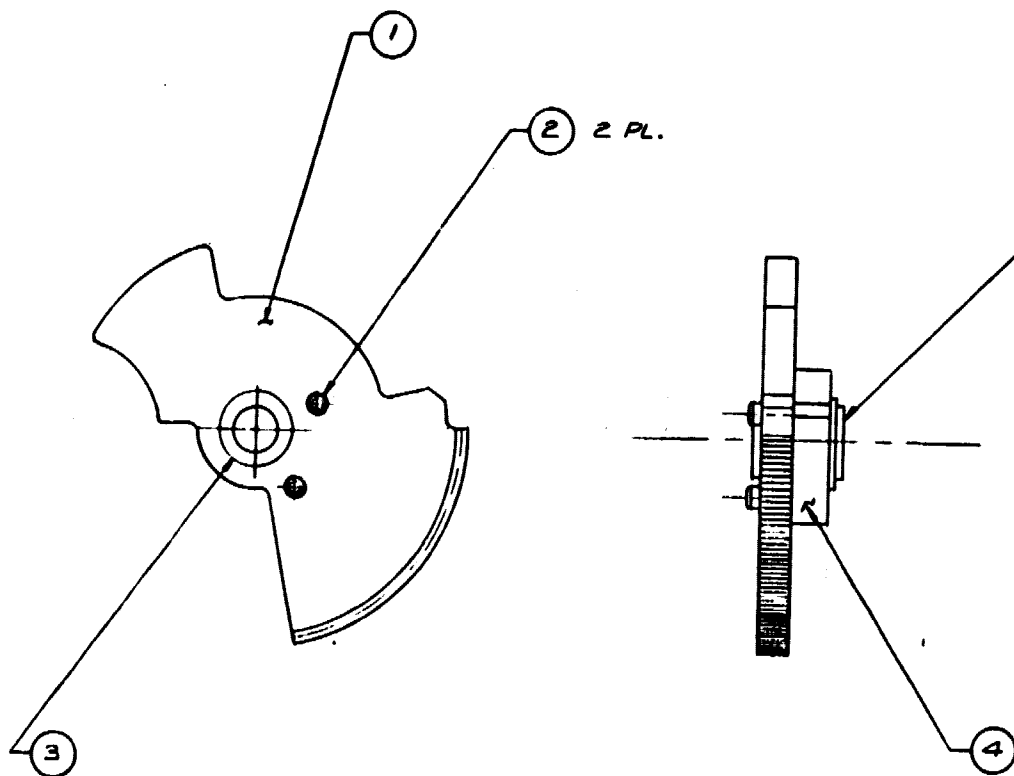


DRILL & TAP THRU FOR LOCKING
THREADED INSERT ~ HELICOIL N#
3585-04CN-0280 (N# 4-40NC x 2.5D.)
OR EQUIV.

NOTE ~
1- REMOVE ALL BURRS & BREAK
ALL SHARP EDGES .01 - .02 R.

2 FOLDOUT FRAME

UNLESS OTHERWISE SPECIFIED		<div style="text-align: center;">  </div> <div style="text-align: center; margin-top: 20px;"> CAM ~ SWITCH </div>	HUNTSVILLE FACILITY 3322 S. MEMORIAL PARKWAY HUNTSVILLE, AL. 35891		DRAWN BY LOUGHEAD
DIMENSIONS ARE IN INCHES DIMENSIONS ON DIMENSIONS					DATE FEB 3 - 81
DECIMALS XX2 .015 XXX2 .005					APPROVED
AL MUM. ALLOY - 6061-T6					CONTRACT 00478
PROTECTIVE FINISH ANODIZE			SCALE 1-1		DRAWING NUMBER 478012
				SHEET OF	



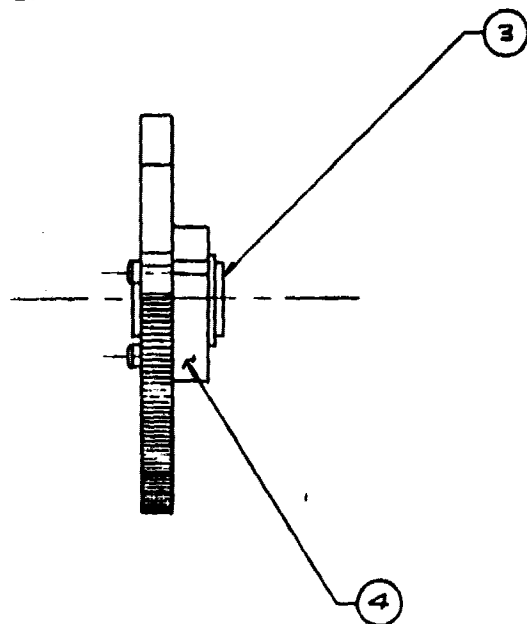
FOLDOUT FRAME

ORIGINAL DESIGN
OF POOR QUALITY

4	1
3	2
2	2
1	1
FIND Nº	QTY
UNLESS OTHERWISE SPECIFIED	
DIMENSIONS ARE IN TOLERANCE ON FRACTIONS	
~	
MATERIAL	
SEE	
FINAL PROTECTIVE	
~	

ORIGINAL PAGE IS
OF POOR QUALITY

2 PL.

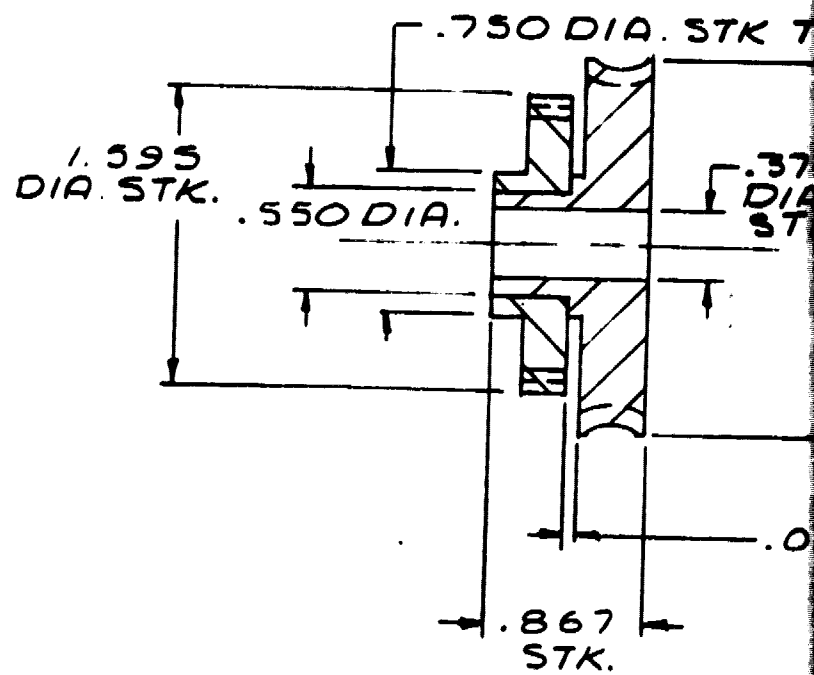
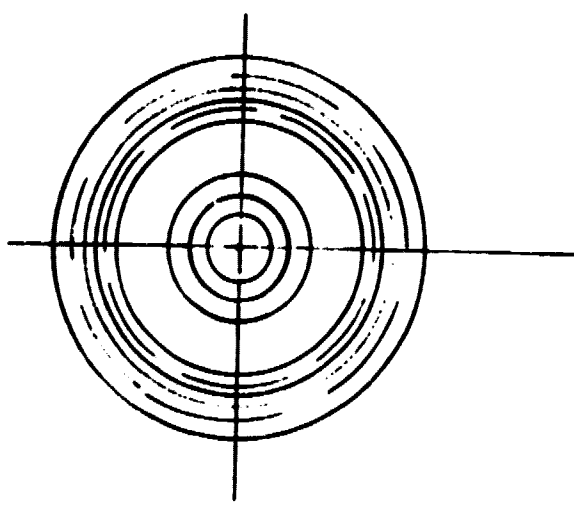


-1 SHOWN
-2 OPPOSITE

2 FOLDBOUT FRAME

4	1	478012	CAM-SWITCH	
3	2	B7-42	BUSHING	BER6
2	2	Y9-S4-AB	SCREW-SOC. HD CAP #40x1/2 LG	BER6
1	1	478011	CAM-LATCH	
FIND N2	QTY.	CAT. N2- DWG. N2	DESCRIPTION	NOTE
PARTS LIST				
UNLESS OTHERWISE SPECIFIED			<div>ESSEX</div> <div>MUNTSVILLE FACILITY 3322 S MEMORIAL PARKWAY MUNTSVILLE AL 36051</div> <div>CAM ASSY</div>	DRAWN BY LOUSHEAD
DIMENSIONS ARE IN INCHES TOLERANCES ON				DATE 8 FEB-54
FRACTIONS				APPROVED
DECIMALS				
ANGLES				
MATERIAL				CONTRACT 00478
SEE P.L.				DRAWING NUMBER 478013
FINAL PROTECTIVE FINISH		SCALE 1-1		SHEET OF

ORIGINAL PAGE IS
OF POOR QUALITY.

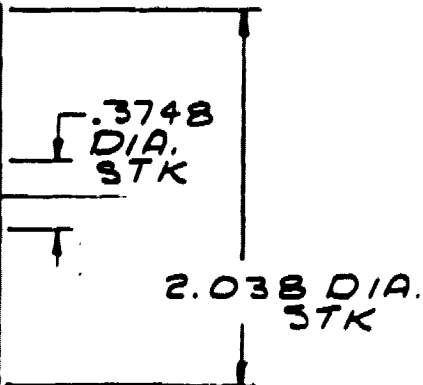


FOLDOUT FRAME

2	1	
1	1	F
FIND NO	QTY	
UNLESS OTHERWISE SPECIFIED		
DIMENSIONS ARE IN INCHES		
TOLERANCE ON FRACTIONS		
XXS - .0005		
XXXS - .0002		
MATERIAL		
SEE PART		
FINAL PROTECTIVE FINISH		
NONE		

ORIGINAL PAGE 18
OF POOR QUALITY

STK TYP.



1 - PRESS FIT (1) ON (2) (.0010 TO .0015 INTERFERENCE).

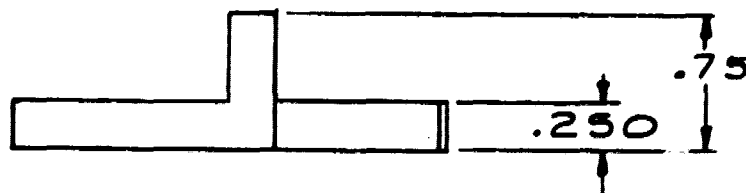
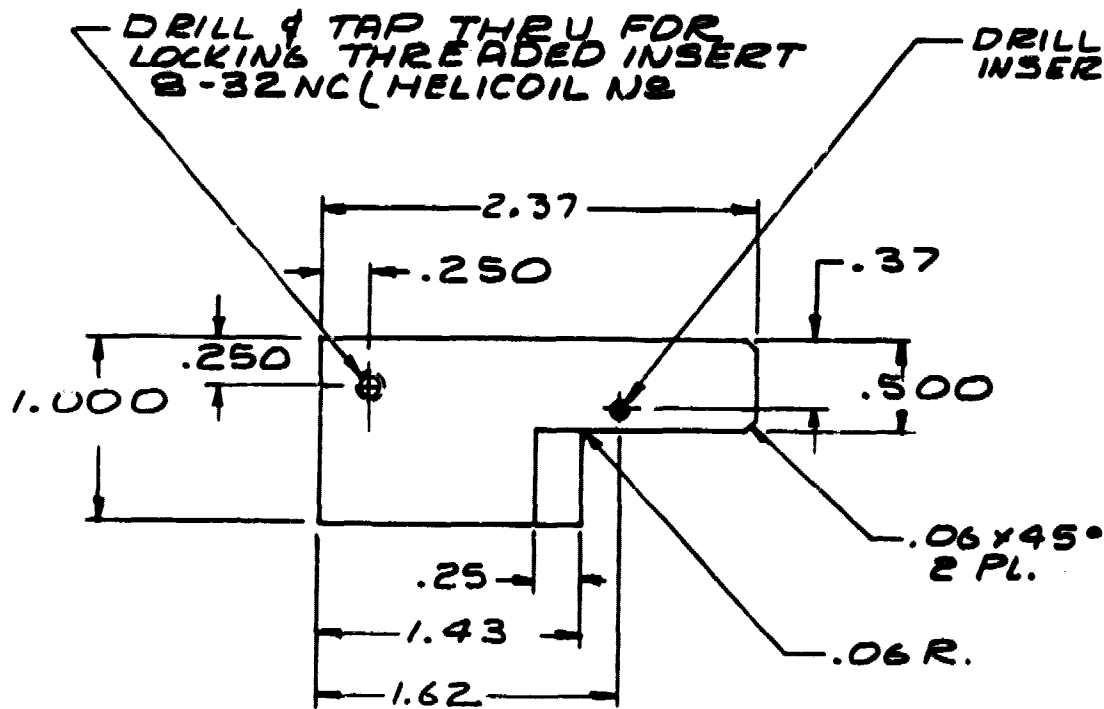
2 - REMOVE ALL BURRS & BREAK ALL SHARP EDGES.

1	W16B35-530	WHEEL (WORM)	BER6
1	P20533-30	GEAR	BER6
QTY	CAT NO	DESCRIPTION	NOTE

PARTS LIST

UNLESS OTHERWISE SPECIFIED		<div style="border: 1px solid black; padding: 5px; display: inline-block;"> ESSEX </div> <p>HUNTSVILLE FACILITY 3322 S. MEMORIAL PARKWAY HUNTSVILLE, AL. 35801</p>	DRAWN BY LOUGHMAN
DIMS ARE IN INCHES DECIMALS ANGLES			DATE 4-11-84
DECIMALS ANGLES			APPROVED [Signature]
DECIMALS ANGLES			CONTRACT 80478
SEE PL.		GEAR ASSY	DRAWING NUMBER 478016
OBJECTIVE FINISH NONE	SCALE 1-1		SHEET OF

2 FOLDOUT FRAME



-1 SHOWN
-2 OPPOSITE

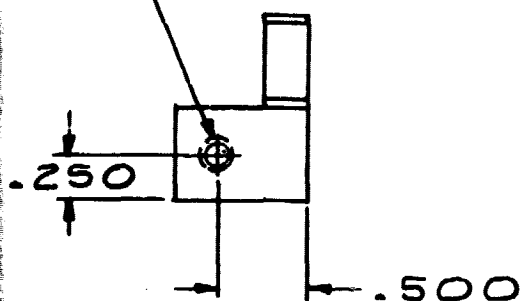
ORIGINAL PAGE IS
OF POOR QUALITY

FOLDOUT FRAME

UNLESS OTHERWISE SPECIFIED	
DIMENSIONS ARE IN INCHES	
TOLERANCE ON	
FRACTIONS	
~	XXX
MATERIAL	
ALUM A	
FINAL PROTECTIVE FINISH	
HARD ANOD	

TAP THRU FOR LOCKING THREADED
#2-40 NC (HELICOIL N2)

DRILL & TAP THRU FOR LOCKING THREADED
INSERT ~ 10-32 NF (HELICOIL N2)



ORIGINAL PART
OF POOR QUALITY

NOTE~

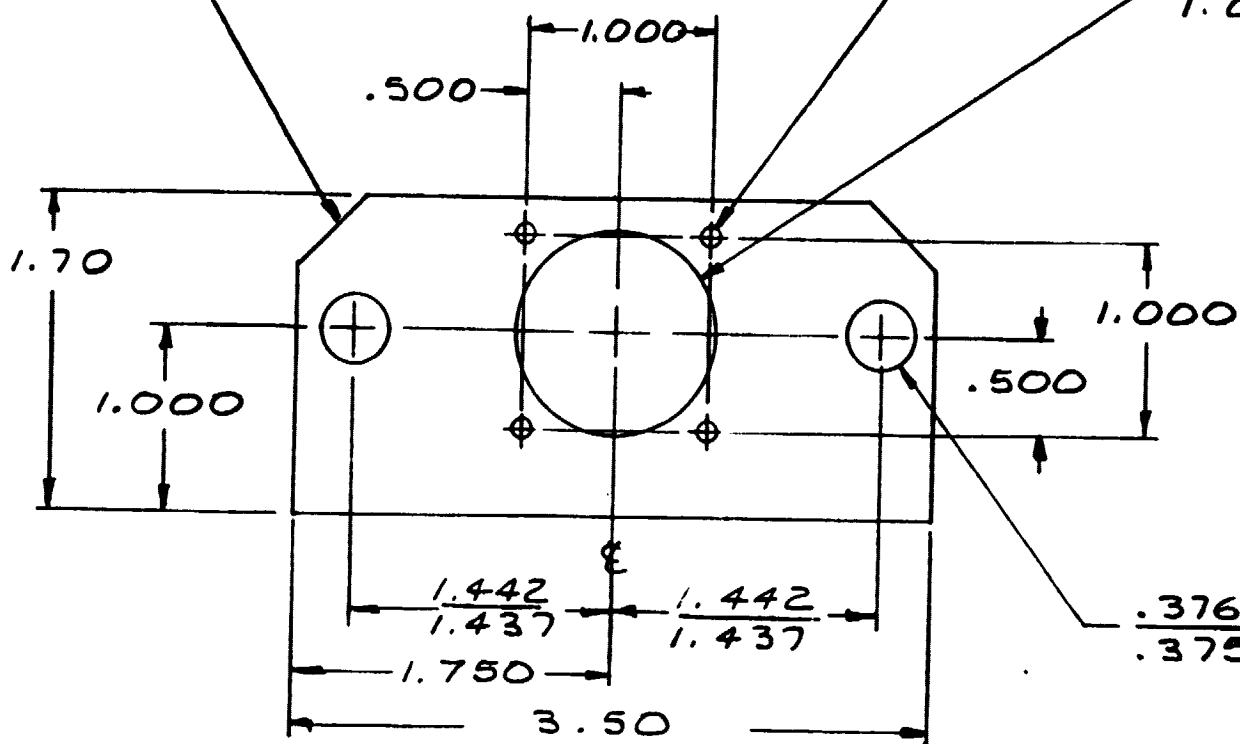
1- REMOVE ALL BURRS & BREAK ALL
SHARP EDGES .01-.02 R.

2 FOLDOUT FRAME

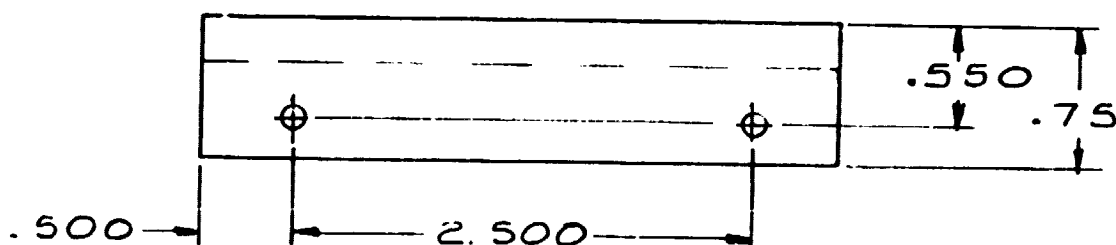
UNLESS OTHERWISE SPECIFIED		<div style="border: 1px solid black; padding: 5px; display: inline-block;"> ESSEX </div> <p>HINTSVILLE FACILITY 22 S. MEMORIAL PARKWAY HINTSVILLE, AL. 35801</p>	DRAWN BY LOUGHEAD
DIMENSIONS ARE IN INCHES			DATE 2 APRIL 86
TOLERANCE ON			APPROVED <i>[Signature]</i>
FRACTIONS	DECIMALS ANGLES		CONTRACT 00478
~	XX2 .015 XXX2 .005 ~		DRAWING NUMBER 478017
MATERIAL ALUM ALLOY 6061-T6		<p style="font-size: 2em; text-align: center;">SLIDER</p>	SHEET OF
FINISH HARD ANODIZE	SCALE 1-1		

7.38 x 45° 2 PL

ORIGINAL PAGE 19
OF POOR QUALITY

$$\frac{1.069}{1.064} \text{ DIA}$$


$\frac{.376}{.375}$ DIA. TH



1

**DIMENSIONS ARE IN INCHES
TOLERANCE ON**

DEC

XXX

萬萬萬

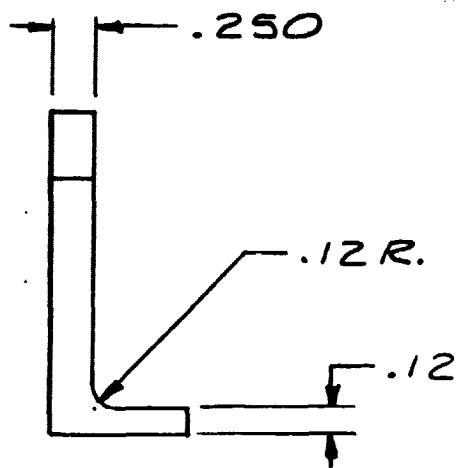
ALUM A

CLEAR AN

28 DIA.) DRILL THRU
ES

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OF POOR QUALITY

069
064 DIA. THRU



6/5 DIA. THRU 2 PL.

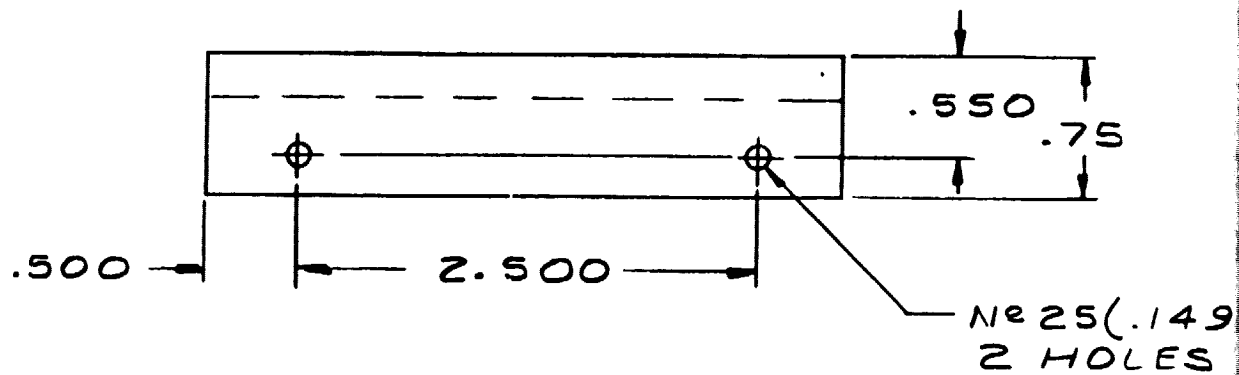
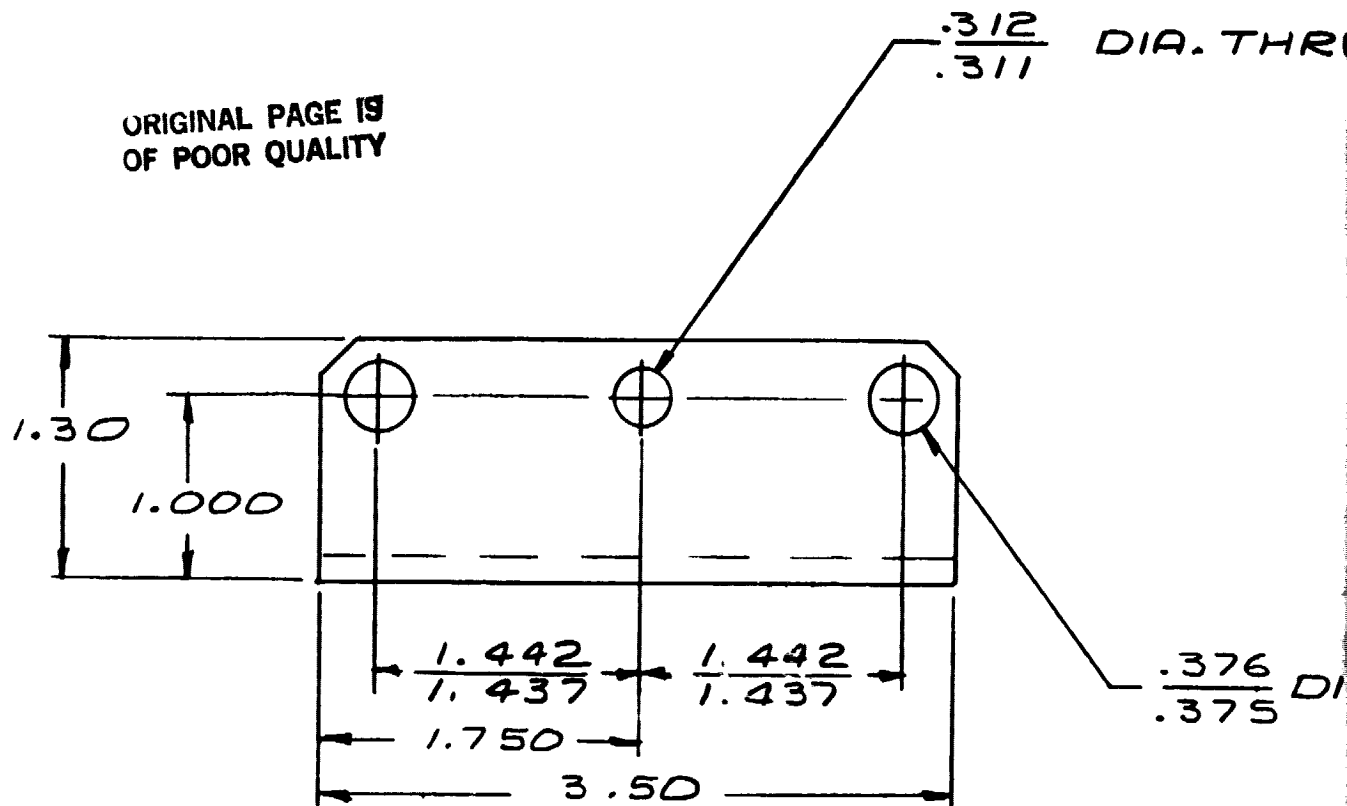
2 FOLDOUT FRAME

NOTE ~

1- REMOVE ALL BURRS & BREAK
ALL SHARP EDGES .01-.02 R.

UNLESS OTHERWISE SPECIFIED		<div style="text-align: center;">ESSEX</div> <div style="text-align: center;">HUNTSVILLE FACILITY 3322 S. MEMORIAL PARKWAY HUNTSVILLE, AL. 35801</div> <div style="text-align: center; font-size: 2em; margin-top: 20px;">MOTOR MOUNT</div>	DRAWN BY LOUGHHEAD
DIMENSIONS ARE IN INCHES TOLERANCE ON FRACTIONS			DATE 9-18-84
DECIMALS .XX2 .015 .XXX2 .005	ANGLES 1°		APPROVED <i>[Signature]</i>
MATERIAL ALUM ALLOY 6061- T6			CONTRACT 00478
AL PROTECTIVE FINISH CLEAR ANODIZE	SCALE 1-1		DRAWING NUMBER 478018
		SHEET	OF

ORIGINAL PAGE 19
OF POOR QUALITY

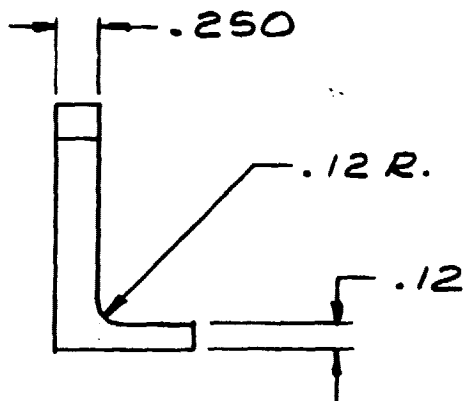


FOLDOUT FRAME

UNLESS OTHERWISE SPECIFIED	
DIMENSIONS ARE IN INCHES	
TOLERANCE ON	DECIMALS
FRACTIONS	XX 2 -
	XXX 2 -
MATERIAL	
ALUM. 6061-T6	
FINAL PROTECTIVE FINISH	
CL. ANOD.	

IA. THRU

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OF POOR QUALITY



.376
.375 DIA. THRU 2 PL.

NOTE ~

1- REMOVE ALL BURRS & BREAK
ALL SHARP EDGES .01-.02R.

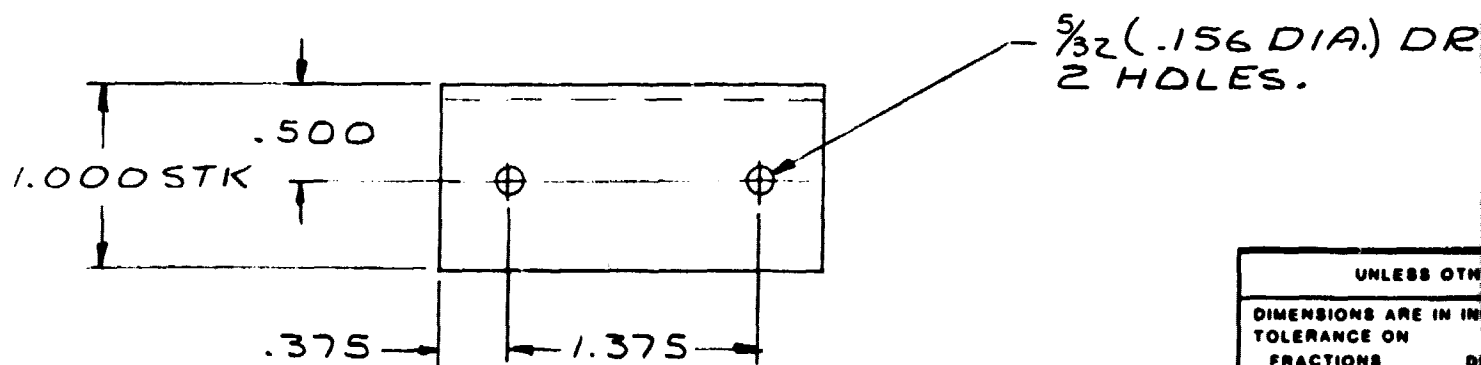
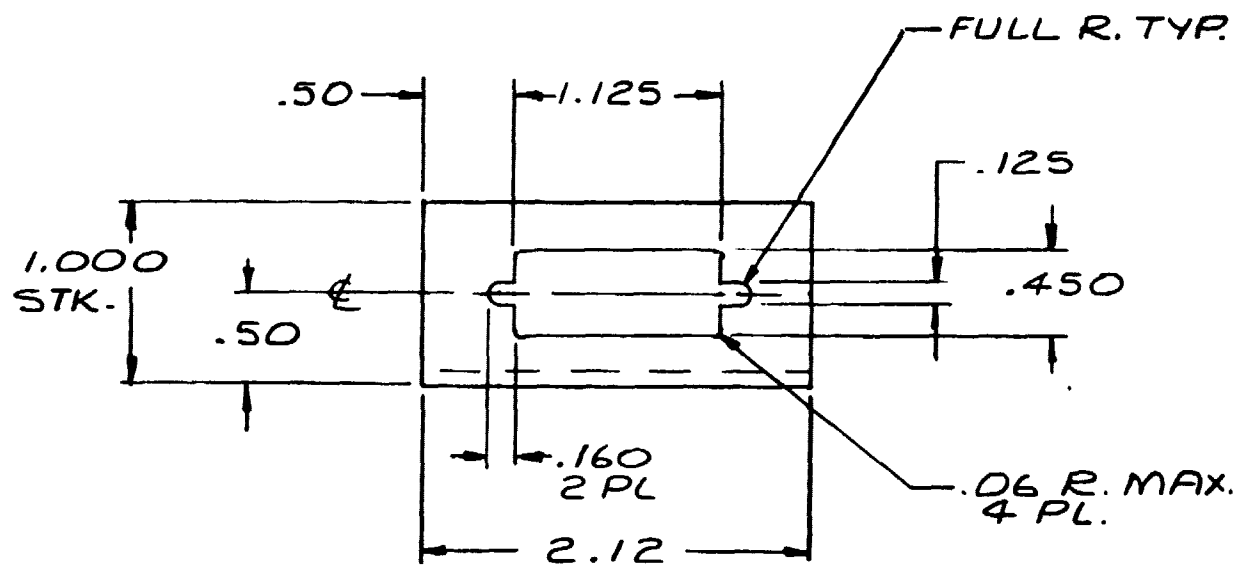
.75

25(.149 DIA.) DRILL THRU
HOLES

2 FOLDOUT FRAME

UNLESS OTHERWISE SPECIFIED			HUNTSVILLE FACILITY 3322 S. MEMORIAL PARKWAY HUNTSVILLE, AL. 35801	DRAWN BY LOUGHEAD
DIMENSIONS ARE IN INCHES TOLERANCES ON FRACTIONS DECIMALS ANGLES ~ XX2 .015 10 XXX2 .005				DATE 4-18-84
MATERIAL ALUM. ALLOY 6061-T6		BRACKET	APPROVED 	
PROTECTIVE FINISH CL. ANODIZE			CONTRACT 00478	
SCALE 1-1			DRAWING NUMBER 478019	
			SHEET OF	

FOLDOUT FRAME

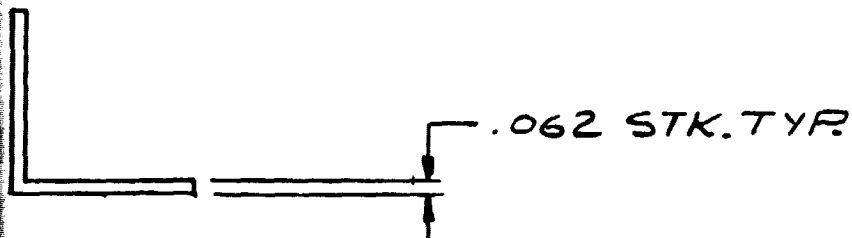


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UNLESS OTHERWISE SPECIFIED	
DIMENSIONS ARE IN INCHES	
TOLERANCE ON DIMENSIONS	
FRACTIONS	DIMENSIONS
~	XXX
MATERIAL	
ALUM. ALL	
FINAL PROTECTIVE FINISH	
CLEAR AN	

ORIGINAL PAGE 19
OF POOR QUALITY

2 FOLDOUT FRAME

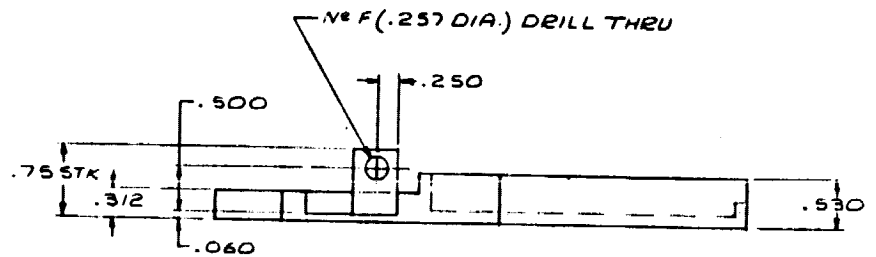
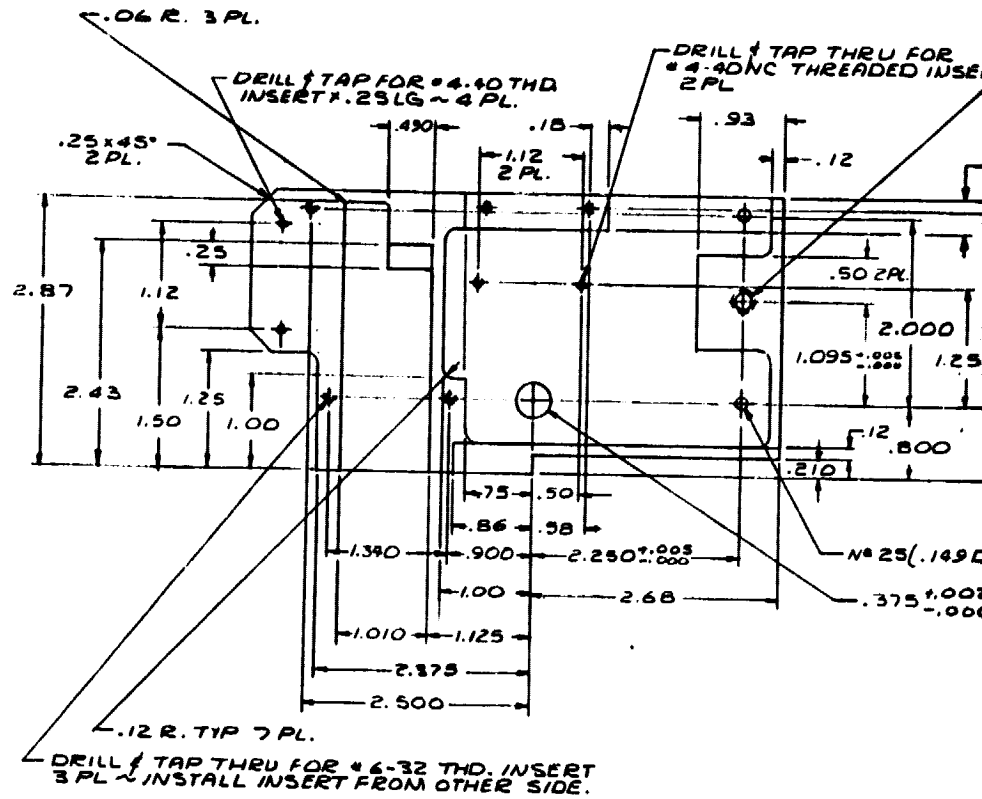
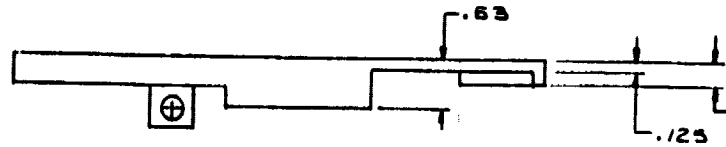


NOTE ~
1- REMOVE ALL BURRS & BREAK
ALL SHARP EDGES. 01-.02 R.

DIA.) DRILL THRU
S.

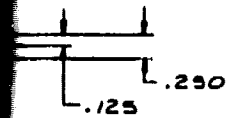
UNLESS OTHERWISE SPECIFIED		<div style="border: 1px solid black; padding: 2px; display: inline-block;">ESSEX</div>	HUNTSVILLE FACILITY 3322 S. MEMORIAL PARKWAY HUNTSVILLE, AL. 35801		DRAWN BY LOUGHEAD
DIMENSIONS ARE IN INCHES TOLERANCE ON FRACTIONS DECIMALS ANGLES ~ .XX2 .015 ~ .XXX2 .005			BRACKET ~ CONNECTOR	DATE 4-18-84	APPROVED <i>[Signature]</i>
MATERIAL ALUM. ALLOY 6061-T6		CONTRACT 00478			
SURFACE FINISH CLEAR ANODIZE		DRAWING NUMBER 478020			
SCALE 1-1		SHEET OF			

ORIGINAL PAGE 19
OF POOR QUALITY

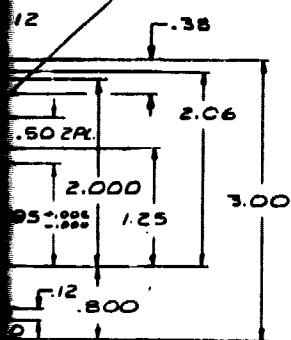


FOLDOUT FRAME

ORIGINAL PAGE 12
OF POOR QUALITY



THRU FOR
READED INSERT DRILL & TAP THRU FOR 1/4-20NC
THREADED INSERT



Nº 25 (.149 DIA.) DRILL THRU 2 PL.
.375 \pm .002 DIA. THRU

NOTE ~

1- REMOVE ALL BURRS & BREAK ALL SHARP
EDGES .01-.02 R.

2- RH 478021-1 SHOWN
LH 478021-2 OPPOSITE

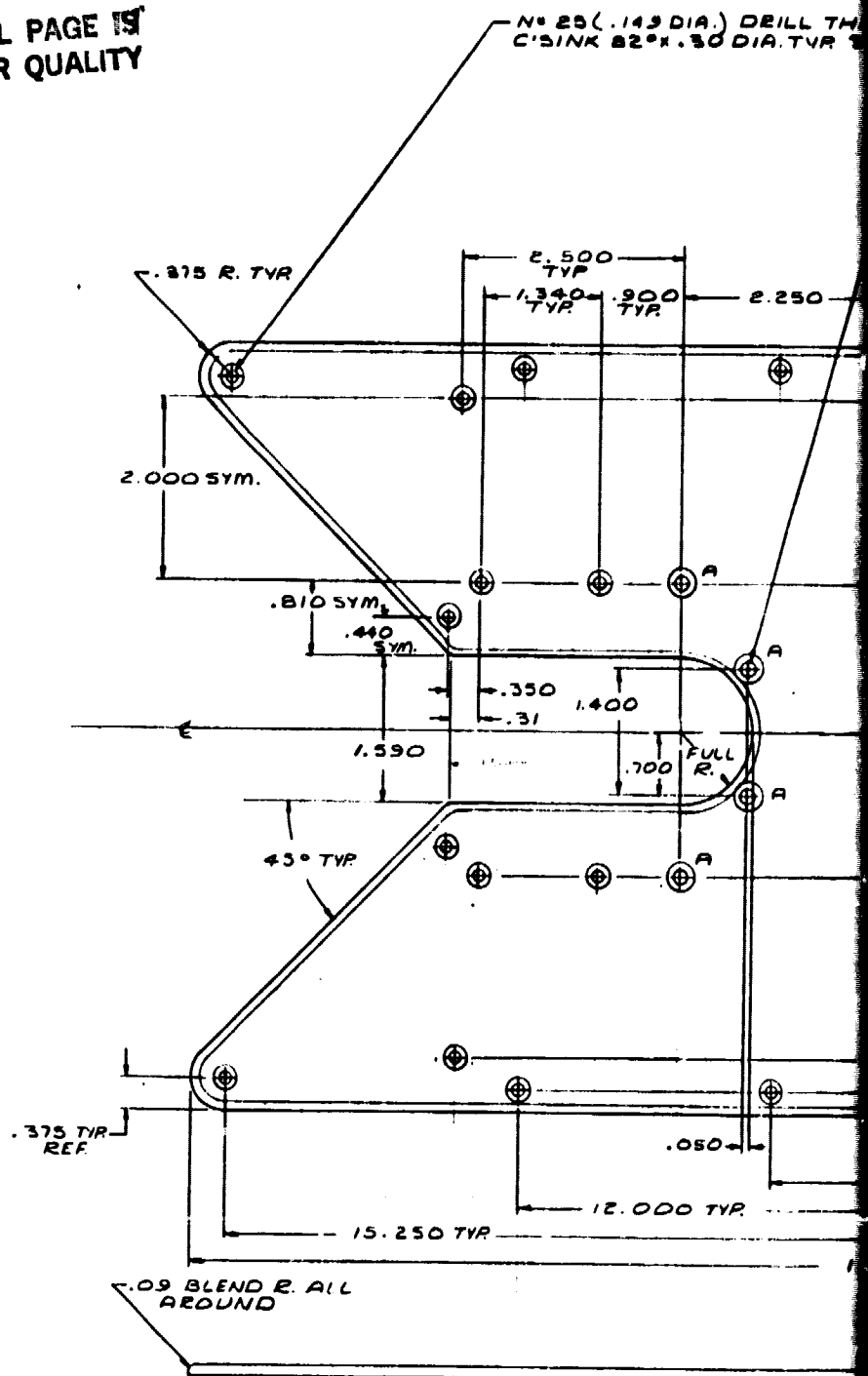


2 FOLDOUT FRAME

UNLESS OTHERWISE SPECIFIED		ESSEX HUNTSVILLE FACILITY 2020 S. HUNTSVILLE PARKWAY HUNTSVILLE, AL 35891	DRAWN BY J. J. HAY
DIMENSIONS ARE IN INCHES TOLERANCES ON FRACTIONS DECIMALS ANGLES .015 .015 1/2			DATE 8-30-88
MATERIAL AL ALLOY 6061-T6			APPROVED J. J. HAY
FINAL PROTECTIVE COAT HARD ENAMEL .87015 MIL THK			CONTRACT 010478
SCALE 1-1			DRAWING NUMBER 478021
			SHEET OF

LATCH MOUNT

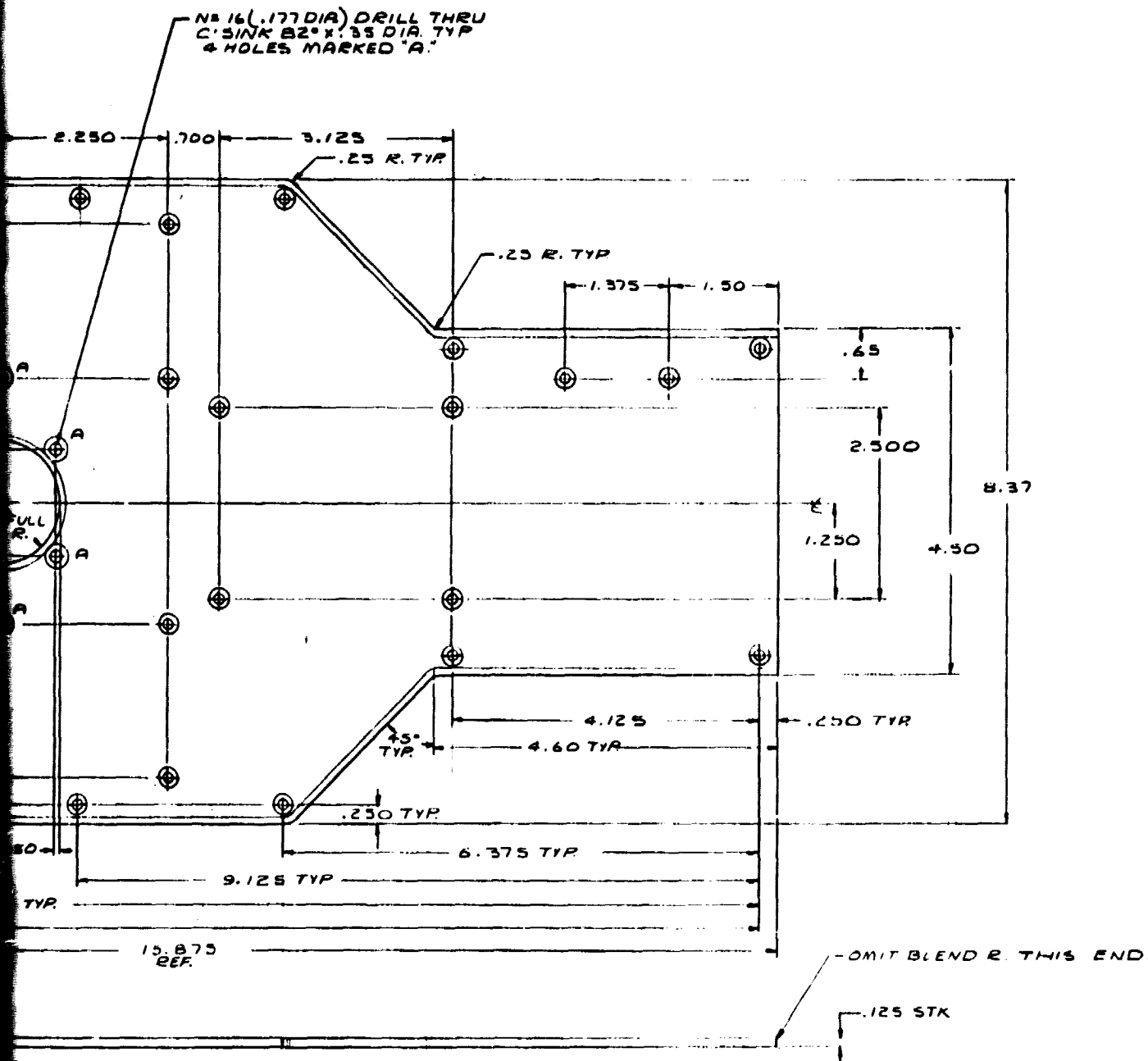
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OF POOR QUALITY



FOLDOUT FRAME

A.) DRILL THRU
30 DIA. TYP 30 PL.

ORIGINAL PAGE 13
OF POOR QUALITY



NOTE~

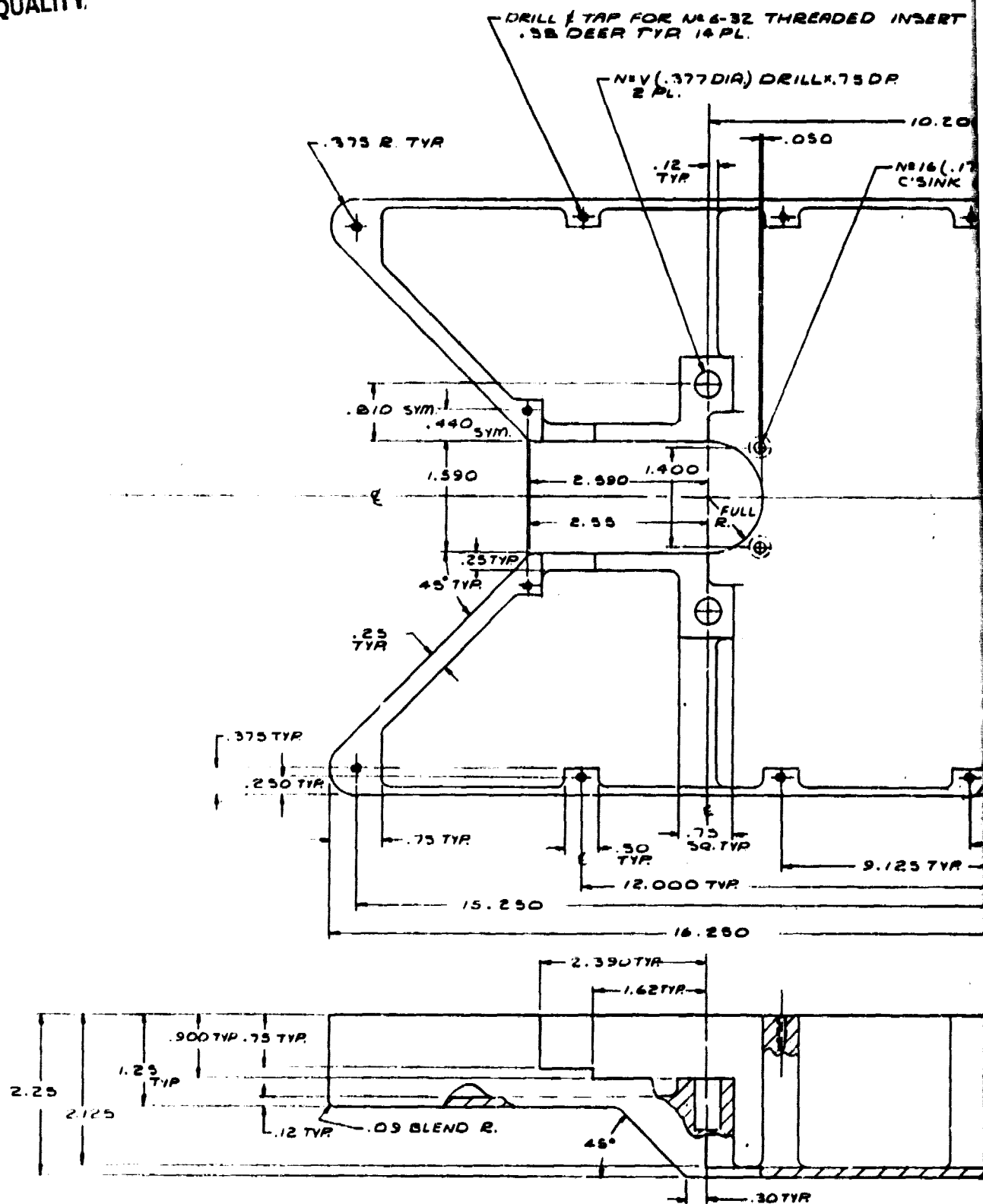
1. REMOVE ALL BURRS / BREAK
ALL SHARP EDGES

2. HARD ANODIZE ALL OVER ~
PAINT WHITE ON SURFACE SHOWN

2 FOLDOUT FRAME

UNLESS OTHERWISE SPECIFIED		ESSEX		MONTICELLO FACILITY 2000 S. MEMORIAL PARKWAY MONTICELLO AL 36081		WORK OF C. D. H. / FAO	
DIMENSIONS AND TOLERANCES TOLERANCE ON FRACTIONS		DECIMALS ANGLES 1/16 0.03 1/8 0.05 1/4 0.125 1/2 0.25 1 0.5 2 1.0 4 2.0 8 4.0 16 8.0 32 16.0 64 32.0 128 64.0 256 128.0 512 256.0 1024 512.0 2048 1024.0 4096 2048.0 8192 4096.0 16384 8192.0 32768 16384.0 65536 32768.0 131072 65536.0 262144 131072.0 524288 262144.0 1048576 524288.0 2097152 1048576.0 4194304 2097152.0 8388608 4194304.0 16777216 8388608.0 33554432 16777216.0 67108864 33554432.0 134217728 67108864.0 268435456 134217728.0 536870912 268435456.0 1073741824 536870912.0 2147483648 1073741824.0 4294967296 2147483648.0 8589934592 4294967296.0 17179869184 8589934592.0 34359738368 17179869184.0 68719476736 34359738368.0 137438953472 68719476736.0 274877906944 137438953472.0 549755813888 274877906944.0 1099511627776 549755813888.0 2199023255552 1099511627776.0 4398046511104 2199023255552.0 8796093022208 4398046511104.0 17592186044416 8796093022208.0 35184372088832 17592186044416.0 70368744177664 35184372088832.0 140737488355328 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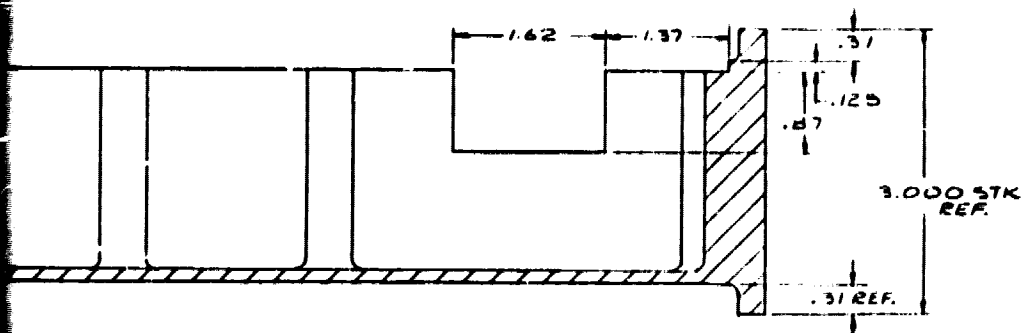
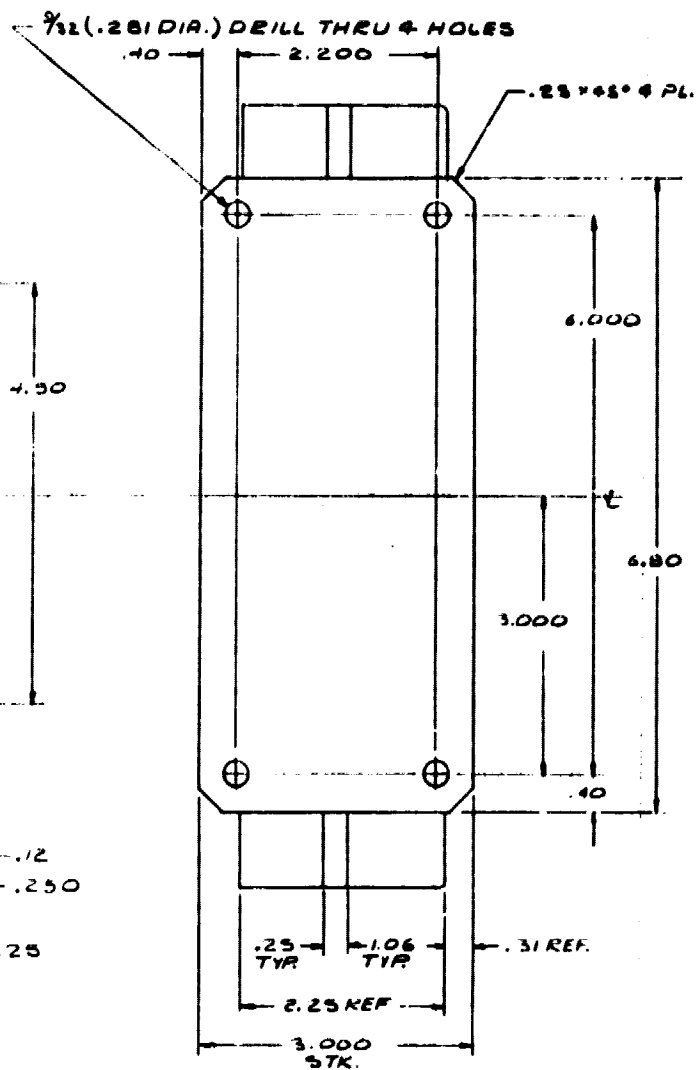
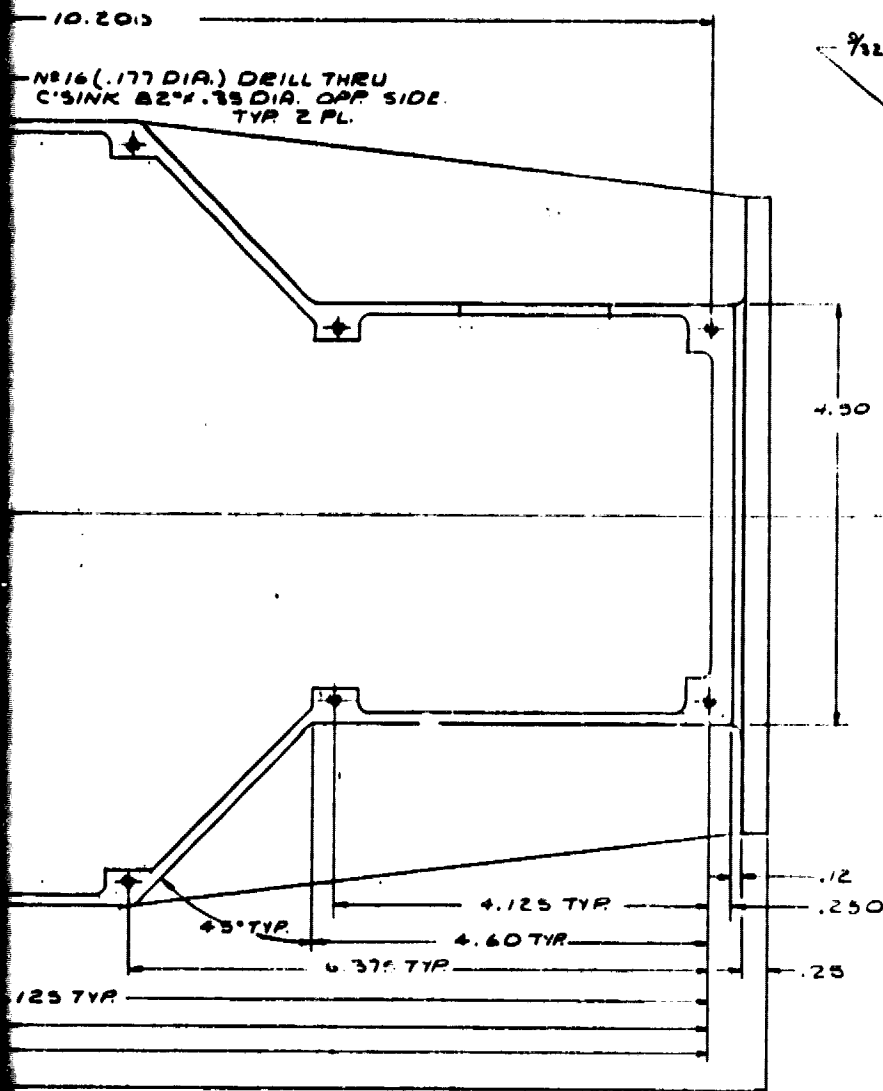


FOLDOUT FRAME

NOTE ~
1- REMOVE ALL SHAPE
2- UNLESS ALL FILL
3- HARD A PAINT WHITE

INSERT

ORIGINAL PAGE 10
OF POOR QUALITY

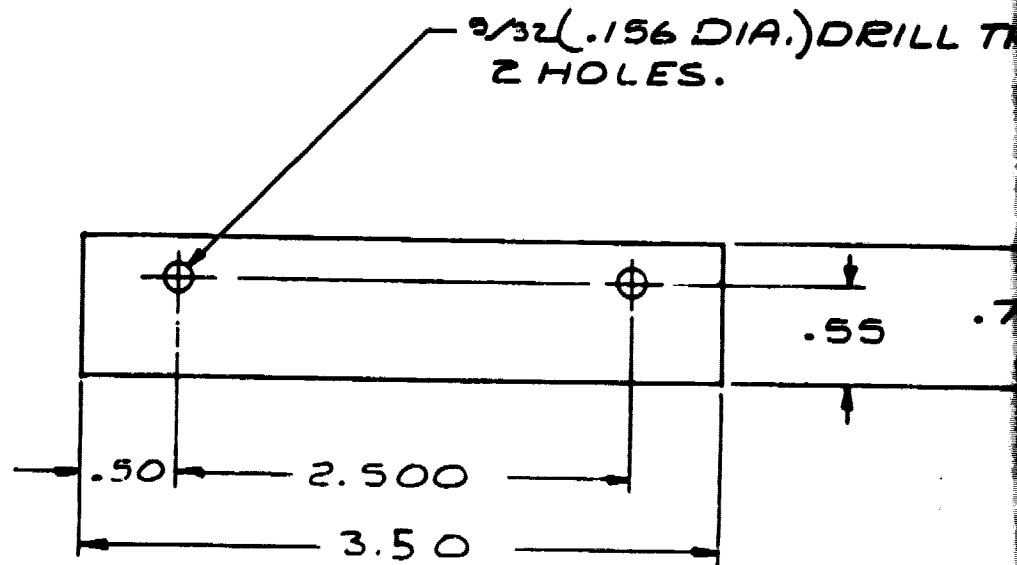


FOLDOUT FRAME

NOTE~
- REMOVE ALL BURRS & BREAK
ALL SHARP EDGES .01-.02 R
- UNLESS OTHERWISE SHOWN~
ALL FILLETS .12 R
HARD ANODISE ALL OVER~
PAINT EXTERIOR SURFACES
WHITE.

UNLESS OTHERWISE SPECIFIED		ESSEX		MATERIALS SECTION		DRAWN BY J. J. W. 40	
DIMENSIONS ARE IN INCHES		FRACTIONS		DECIMALS		DATE 3-9-84	
~		.015		.005		APPROVED BY J. J. W.	
MATERIAL		FILM ALLOY		6061-T6		CONTRACT 20378	
FINISH PROTECTIVE FINISH		3		1-1		DRAWING NUMBER 478023	
HOUSING				SHEET 1 OF 1			

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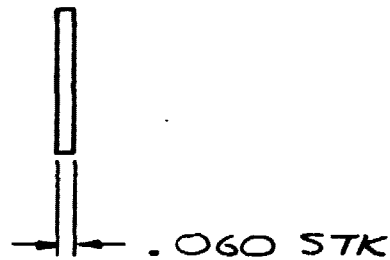
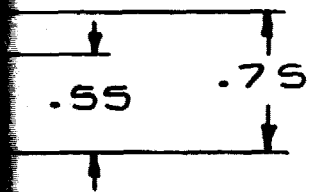


FOLDOUT FRAME

UNLESS OTHERWISE SPECIFIED	
DIMENSIONS ARE IN INCHES	
TOLERANCE ON FRACTIONS	DECIMALS
	MAX. MIN.
	1/16 1/32
MATERIAL	
ALUMINUM ALLOY	
FINAL PROTECTIVE FINISH	
CLEAR ANODIZE	

ORIGINAL PAGE IS
OF POOR QUALITY

DRILL THRU

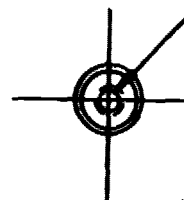
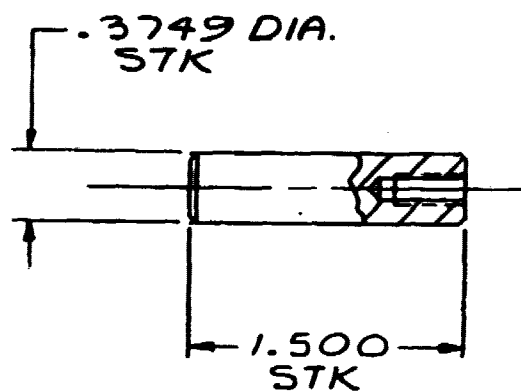


2 FOLDOUT FRAME

C-2

UNLESS OTHERWISE SPECIFIED		ESSEX	HUNTSVILLE FACILITY 3322 S. MEMORIAL PARKWAY HUNTSVILLE, AL. 35801	DRAWN BY LOUGHEAD	
DIMENSIONS ARE IN INCHES				DATE 5-11-84	
TOLERANCE ON				APPROVED 	
FRACTIONS				CONTRACT 00978	
DECIMALS				DRAWING NUMBER 478024	
ANGLES		SHEET			
MATERIAL ALUM ALLOY 6061-T6		OF			
FINAL PROTECTIVE FINISH CLEAR ANODIZE		SCALE 1-1			

ORIGINAL PAGE IS
OF POOR QUALITY



FOLDOUT FRAME

UNLESS OTHERWISE SPECIFIED	
DIMENSIONS ARE IN INCHES	
TOLERANCE ON FRACTIONS	
~	DEC
XX2	~
XXX2	~
MATERIAL	
	2
FINAL PROTECTIVE FINISH	
PASSIVA	

ORIGINAL PAGE IS
OF POOR QUALITY

#8-32 NC TAP x .38 DP

NOTE ~

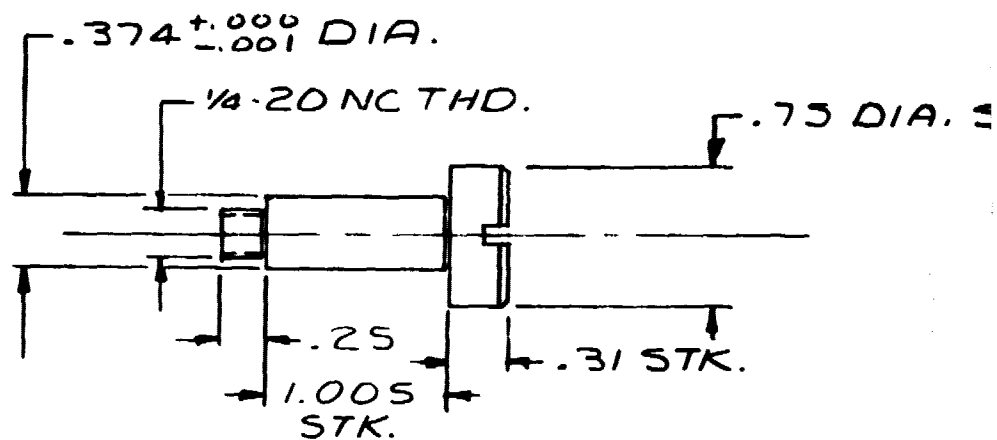
1- REMOVE ALL BURRS & BREAK
ALL SHARP EDGES .01-.02 R

2 MAKE FROM BERG P/N
D21-16.

2 FOLDOUT FRAME

UNLESS OTHERWISE SPECIFIED		ESSEX	HUNTSVILLE FACILITY 3322 S. MEMORIAL PARKWAY HUNTSVILLE, AL. 35801	DRAWN BY LOUGHEAD
DIMENSIONS ARE IN INCHES TOLERANCES ON DIMENSIONS				DATE 5-11-84
DECIMALS XX ± .015 XXX ± .005	ANGLES 10			APPROVED <i>[Signature]</i>
MATERIAL 2				CONTRACT 00478
PROTECTIVE FINISH PASSIVATE	SCALE 1-1			DRAWING NUMBER 478025
				SHEET OF

ORIGINAL PAGE 13
OF POOR QUALITY



FOLDOUT FRAME

UNLESS OTHERWISE SPECIFIED	
DIMENSIONS ARE IN INCHES	
TOLERANCE ON	
FRACTIONS	DECIMALS
$\frac{1}{16}$.005
$\frac{1}{8}$.010
$\frac{1}{4}$.015
$\frac{3}{8}$.020
$\frac{1}{2}$.030
$\frac{3}{4}$.040
1	.050
MATERIAL	
MAKE FROM	
PL 45-3	
FINAL PROTECTIVE FINISH	
PASSIVATED	

ORIGINAL PAGE IS
OF POOR QUALITY

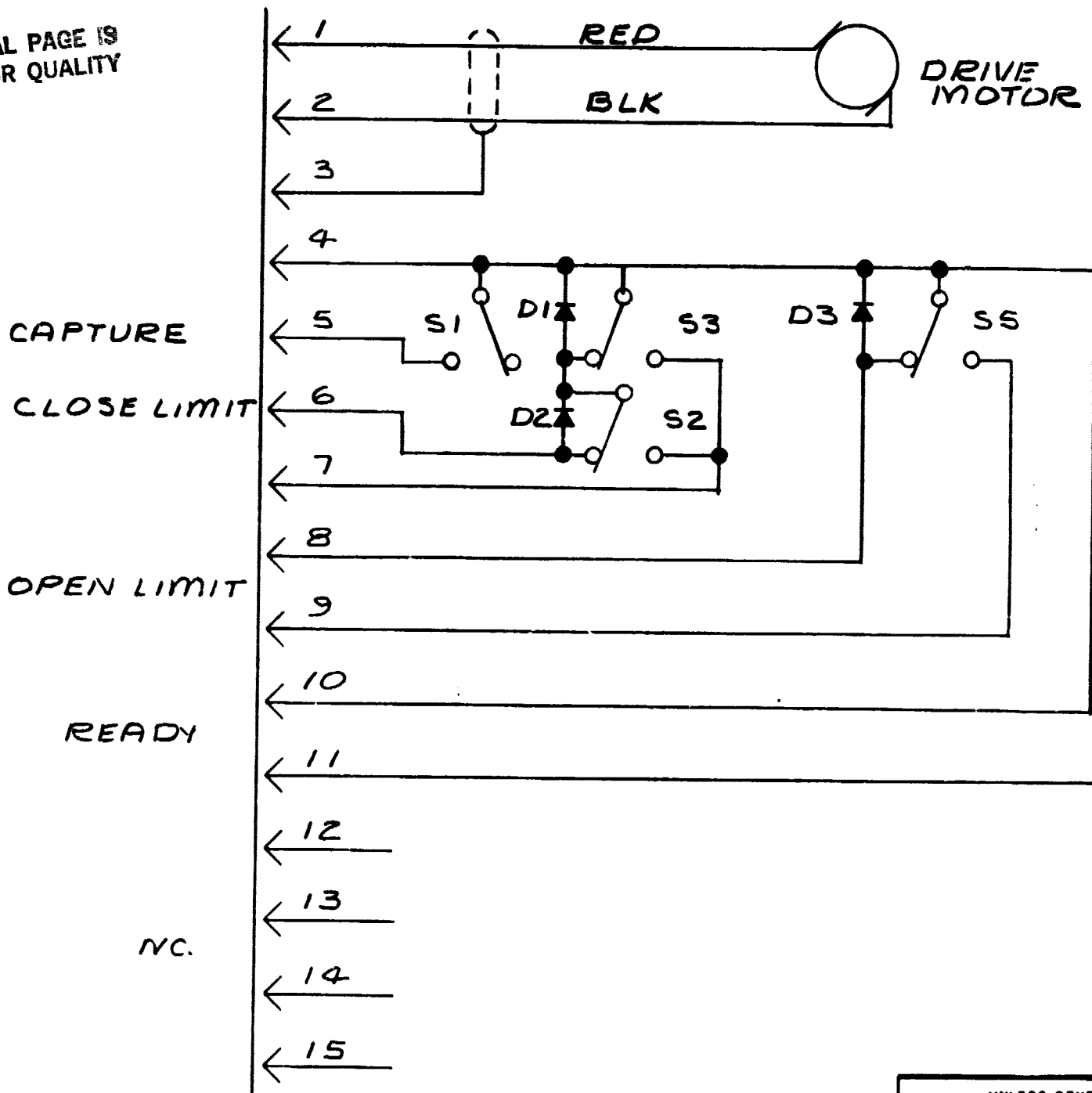
3 DIA. STK.

NOTE~
1-REMOUE ALL BURRS & BREAK
ALL SHARP EDGES.

~ FOLDOUT FRAME

UNLESS OTHERWISE SPECIFIED		<div>ESSEX</div> SHOULDER SCREW (MOD.)	HUNTSVILLE FACILITY 3322 S. MEMORIAL PARKWAY HUNTSVILLE, AL. 35801	DRAWN BY LOUGHEAD
DIMENSIONS ARE IN INCHES TOLERANCE ON FRACTIONS DECIMALS ANGLES ~ .015 ~ .005				DATE 5-10-89
MATERIAL MAKE FROM BERG N6 PL 45-3				APPROVED Fah
SURFACE FINISH PASSIVATE			SCALE 1-1	CONTRACT 00478
				DRAWING NUMBER 478026
			SHEET	OF

ORIGINAL PAGE IS
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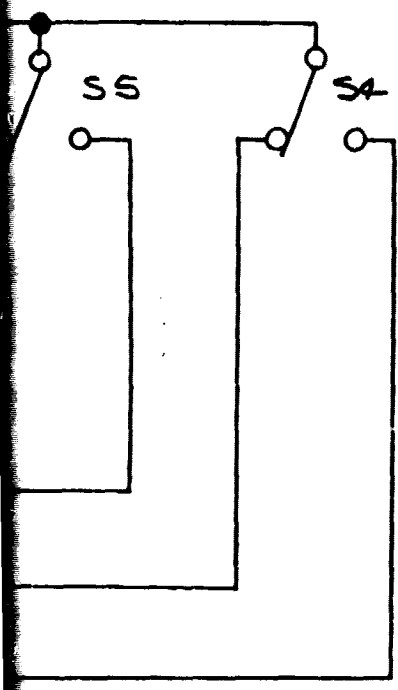


FOLDOUT FRAME


UNLESS OTHERWISE SPECIFIED	
DIMENSIONS ARE IN INCHES	DECIMALS
TOLERANCE ON FRACTIONS	XX 2 XXX 2
MATERIAL	
FINAL PROTECTIVE FINISH	

DRIVE
MOTOR

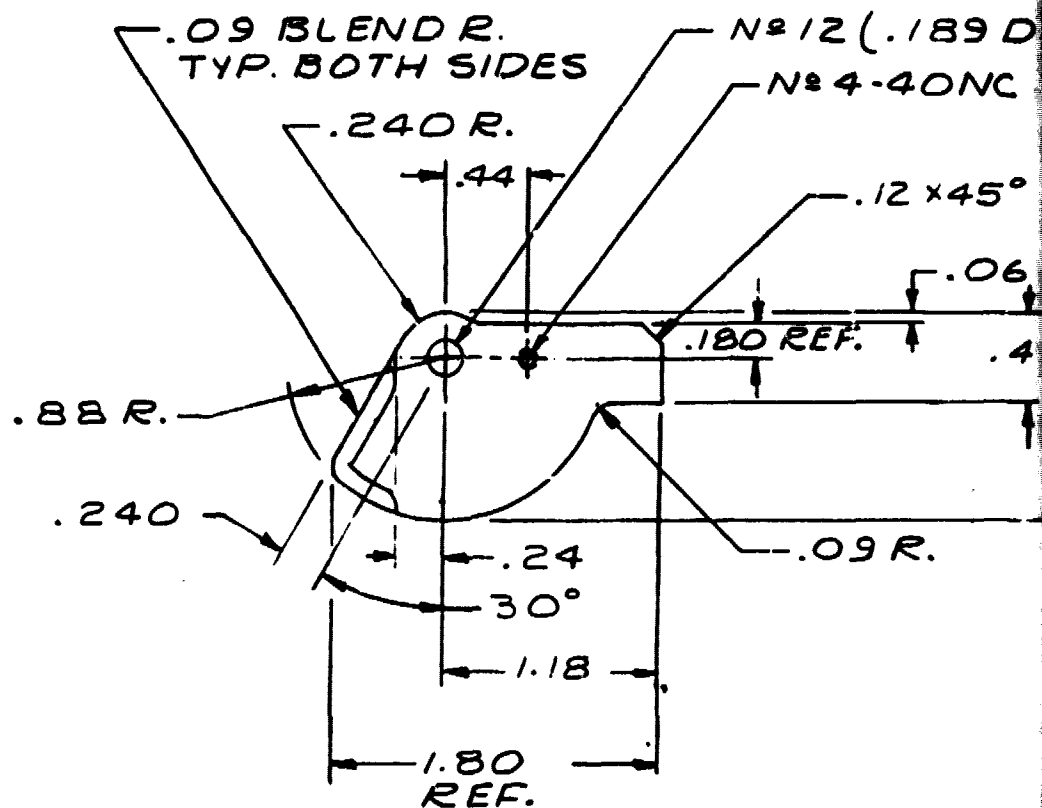
ORIGINAL PAGE 13
OF POOR QUALITY



2 FOLDOUT FRAME

UNLESS OTHERWISE SPECIFIED		<div><p>HUNTSVILLE FACILITY 3322 S. MEMORIAL PARKWAY HUNTSVILLE, AL. 35891</p></div> <div><p>ELECTRICAL SCHEMATIC ~ DOCKING LATCH</p></div>	DRAWN BY LOUGHHEAD	
DIMENSIONS ARE IN INCHES			DATE AUG 20-80	
TOLERANCE ON FRACTIONS	DECIMALS		ANGLES	APPROVED
~	XX2 ~ XXX2		~	CONTRACT 00478
MATERIAL			~	DRAWING NUMBER 478027
PAINT PROTECTIVE FINISH		SCALE	SHEET OF	
~		~		

ORIGINAL PAGE 13
OF POOR QUALITY



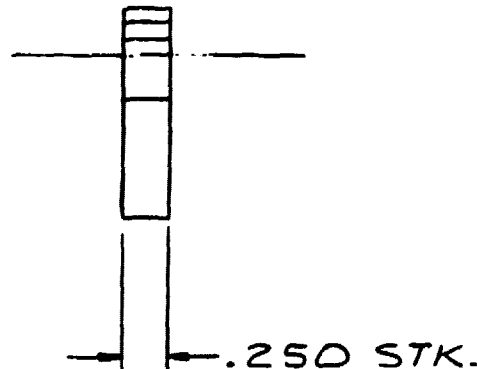
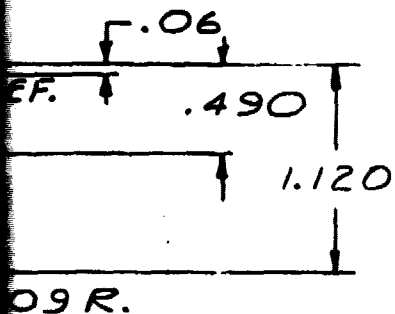
FOLDOUT FRAME

UNLESS OTHERWISE SPECIFIED	
DIMENSIONS ARE IN INCHES	
TOLERANCE ON	
FRACTIONS	DECIMALS
~	XX2 .
	XXX .
MATERIAL	
303 CRES	
FINAL PROTECTIVE FINISH	
PASSIVATE	

ORIGINAL DRAWING
OF POOR QUALITY

1/2 (.189 DIA.) DRILL THRU
4-40NC TAP THRU

.12 x 45°



NOTE ~
1- REMOVE ALL BURRS & BREAK
ALL SHARP EDGES .01-.02 R.

2 FOLDOUT FRAME

UNLESS OTHERWISE SPECIFIED		ESSEX	MUNTSVILLE FACILITY 3322 S. MEMORIAL PARKWAY MUNTSVILLE, AL. 35601	DRAWN BY LOUGHEAD
DIMENSIONS ARE IN INCHES TOLERANCES ON DIMENSIONS				DATE MAY 4 '84
DECIMALS XX ± .015 XXX ± .005		PAWL	APPROVED	
ANGLES 1/2°			CONTRACT 00478	
MATERIAL 103 CRES			DRAWING NUMBER 478030	
PROTECTIVE FINISH PASSIVATE	SCALE 1-1		SHEET OF	